ASSESSING DATA QUALITY IN THE COMMUNITY HEALTH WORKER (CHW) PROGRAM IN EASTERN PROVINCE, RWANDA

By

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Dissertation abstract

Background

In order to achieve global development goals, the international community has called for the use of community health workers (CHWs) to deliver important health services.

CHWs are routinely collecting large amounts of information. As program managers use these data to monitor and evaluate community-based activities, achieving and maintaining high data quality is critical.

Objectives

Measuring: 1) data accuracy of household registers compared to household interviews and client records in one district; 2) data reliability of monthly village reports compared to program registers in three districts; and 3) CHW and program factors related to data accuracy and reliability.

Methods

We used lot quality assurance sampling (LQAS) to determine data quality May 2011-June 2012.

We randomly sampled: 1) six CHWs per cell, six households per CHW and classified cells as having 'poor' or 'good' accuracy for household registers based on five health indicators and a composite one, calculating point estimates by health center; and 2) 19 villages per health center classifying health centers as having ‘poor’ or ‘good’ reliability for village reports for three program indicators and a composite one, calculating point estimates by district.

We administered a structured interview to CHWs in three districts measuring CHW and program factors, using logistic regression to measure associations with binary dependent variables data accuracy and reliability.

Results

Accuracy of household data varied by health center: point estimates were 61-72% for the composite indicator.

Data reliability was poor across all districts: point estimates for the composite indicator were 26-60%.

CHW having logged a visit to the household in the last month in the household register significantly increased odds of accurate data (OR: 1.71; 95%CI: 1.22, 2.39).

The more sick children seen by CHWs significantly worsened data reliability: for four or more sick children versus none, OR: 0.283; 95%CI: 0.180, 0.445.

Conclusions

Community level data quality is variable in Rwanda, with CHWs generally able to collect data accurately, but not aggregate it correctly due to some program factors. To ensure dependable utilization of information by program managers, we recommend improved supervision and training and LQAS-based routine data quality assessments.

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List of terms and abbreviations

ASM	*Animatrice de santé maternelle* (female CHW responsible for maternal and newborn health activities)
Binôme	One male and one female CHW (per village) primarily carrying out iCCM and other activities
Cell	Administrative unit comprised of ~10 *imidugudu*
CHW	Community health worker
C-LQAS	Cluster Lot Quality Assurance Sampling
Cooperative	Organized group of CHWs at sector (health center) level which receives funding through quarterly PBF and designed as income-generating mechanism for its members
DDCF	Doris Duke Charitable Foundation
DHIS2	District health information system platform in Rwanda including facility- and community-based components
District	Administrative unit comprising ~14 sectors (with at least 1 hospital per district).
DQA	Data quality assessment
EGPAF	Elizabeth Glaser Pediatric AIDS Foundation
The Global Fund	The Global Fund to Fight AIDS, TB and malaria
GoR	Government of Rwanda
HIV/AIDS	Human immunodeficiency virus / acquired immunodeficiency syndrome
HIS	Health information system
HMN	Health Metrics Network
iCCM	Integrated community case management (of malaria, diarrhea and pneumonia in children under five years)
IMB	Inshuti Mu Buzima (PIH's sister organization in Rwanda)
IRC	International Rescue Committee
LQAS	Lot Quality Assurance Sampling
MDG	Millennium Development Goal
MNH	Maternal and newborn health (activities covered by ASMs)
MoH	Ministry of Health
MUAC	Mid-upper arm circumference (measure of malnutrition)
Mutuelle de santé	National community-based insurance scheme
PBF	Performance-based financing
PIH	Partners In Health
RHIS	Routine health information system
RWF	Rwandan franc
Sector	Administrative unit comprising ~4 cells (with at least 1 health center per sector).
SIS	Système d'information sanitaire (MoH HIS)
SISCom	Système d'information de la santé communautaire (MoH

	community HIS)
Sociologue	MoH Global Fund-funded 2-year health center position to coordinate CHW activities
Titulaire	Head of health center
TB	Tuberculosis
Umudugudu/ imidugudu (pl.)	Lowest administrative level comprising ~100 households (village)
U5	[Children] under the age of 5 years
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Chapter 1. Introduction

In 2000, leaders of 189 countries adopted the United Nations Millennium Declaration, thereby committing to "a world with less poverty, hunger and disease, greater survival prospects for mothers and their infants, better educated children, equal opportunities for women, and a healthier environment (United Nations Statistics Division, 2012a)." The progress of the eight Millennium Development Goals (MDGs) are monitored by many more indicators within the Declaration framework to meet targets set to be achieved by 2015 (United Nations Statistics Division, 2012b). MDGs four (reduce child mortality), five (improve maternal health) and six (combat HIV/AIDS, malaria and other diseases) target health-specific interventions (see Appendix 10.1).

In order to achieve these MDGs, the international and scientific communities have called and provide evidence for the use of lay or community health workers (CHWs) to deliver important health services at the community and household levels such as neonatal, child and maternal health and infectious disease prevention and care (Baqui et al., 2009; Bhutta et al., 2005; Bhutta et al., 2010b; Christopher et al., 2011; Darmstadt et al., 2005; Hopkins et al., 2007; Lewin et al., 2010; Rich et al., 2012; WHO/UNICEF, 2004a, 2004b). For example, a 2010 review conducted by the Bhutta et al. (2010) on the role of CHWs towards achieving the MDGs found that through the wide range of activities they carry out, CHWs have indeed contributed to the reduction of child and maternal mortality and burden and cost of tuberculosis (TB) and malaria. Similarly, a Cochrane review conducted by Lewin et al. (2010) found evidence of moderate quality supporting the effectiveness of CHWs in improving TB cure rates; and of low quality for the reduction of child morbidity and mortality.

CHWs are consequently collecting and reporting on a large volume and range of information on a routine basis. In its Framework for Action to strengthen health systems, WHO states (WHO, 2007): "it will be impossible to achieve national and international goals – including the MDGs – without greater and more effective investment in health systems and services." One of the six building blocks of the framework is a well-functioning health information system, which necessarily comprises community-based data.

As these data are being used at all levels to monitor, manage and evaluate community-based activities, achieving and maintaining high data quality is critical within any CHW program. Using data of poor quality can result in lower program effectiveness, inefficient utilization of resources, lack of knowledge about existing system gaps and poor program management. Understanding whether gaps are occurring in data quality versus quality of care is critical to knowing where and how care can be improved. Finally, it is important to grasp whether and under what circumstances CHWs are able to produce data of adequate quality to use these data to identify and improve quality of care and strengthen supervision and management.

There is a relative abundance of both published and grey literature addressing data quality of paper-based and electronic facility-based health information in the sub-Saharan African context alone (Allotey et al., 2000; Bosch-Capblanch et al., 2009; Garrib et al., 2008; Gimbel et al., 2011; Hedt-Gauthier et al., 2012; Makombe et al., 2008; Mate et al., 2009; Otwombe et al., 2007). However, the quality of CHW–reported data and their use for driving improvements in quality of community-based care are largely unknown with few exceptions – in any region (Admon et al., 2013; Helleringer et al., 2010; Mahmood et al., 2010; Otieno et al., 2011). Similarly, few studies have focused on the context within which CHWs collect and report information, or on the factors associated with CHW data quality (Admon et al., 2013; Crispin et al., 2012; Helleringer et al., 2010; Mahmood et al., 2010).

1.1 Research questions and study aims

The research questions of this study are:

1. What is and what factors affect the quality of data collected and reported by community health workers (CHWs) in Eastern Province, Rwanda?

2. Is it feasible to apply the study methodology to routinely assess the quality of data in a community-based health information system?

Specific aims include:

To adapt existing facility-based data quality and health information system assessment tools to develop a methodology to routinely measure data quality in Rwanda's national community-based health information system, and more specifically:

Aim 1. To measure the quality of data (accuracy) collected in the community health household register by CHWs in southern Kayonza district by cell and health center.

Aim 2. To measure the quality of CHW data (reliability) in the *umudugudu* (village) monthly SISCom (système d'information de la santé communautaire or national community health information system) report and integrated community case management (iCCM) register in Kirehe and southern and northern Kayonza districts, by health center and district.

And,

Aim 3. To examine key CHW and program (organizational) factors, including level of program support, time since and type of training, level of education of CHW, time as CHW, and level of supervision, and others associated with specific components (reliability, accuracy) of quality of CHW data as measured in Aims 1 and 2 in Kirehe, southern and northern Kayonza districts.

An additional output of Aims 1 and 2 are simple paper-based tools for community health program managers and supervisors at all levels to routinely and practically assess and analyze CHW data quality in the village reports and household registers (though not included as part of this dissertation).

1.2 Conceptual framework

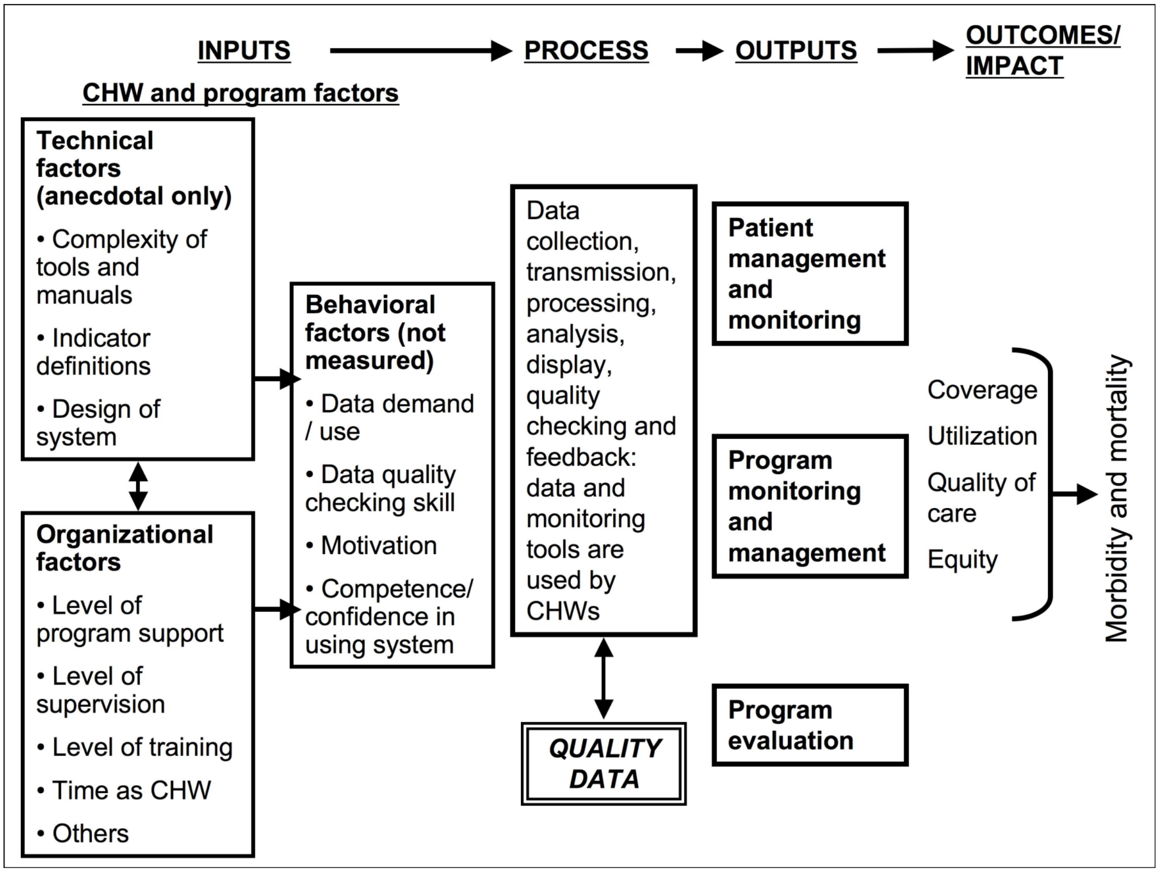
Data collected and reported by CHWs, if practical, complete, accurate and timely, can be used by: 1) CHWs to help care for and monitor community members in their catchment area; 2) supervisors, health facilities and the government at all levels to monitor and manage CHWs, their performance and activities and respond accordingly; and 3) the government to evaluate how CHWs contribute to broader health system goals such as improved health service coverage, utilization and equity, and reduced mortality (supplementing or removing entirely the use of more costly alternative data sources). The conceptual framework below (Figure 1) illustrates how these components fit together.

The framework is organized as a logic model, drawing from and modifying the PRISM (Performance of Routine Information System Management) framework as proposed by Aqil et al. (2009). Inputs are broadly represented by a number of both measured and unmeasured CHW and program factors and further broken down into three types of determinants of a well-performing routine health information system (RHIS): 1) technical factors (anecdotal only) are those related to the design and technology of the overall RHIS; 2) organizational factors (measured) include those describing the health service delivery context within which CHWs work; and 3) behavioral factors (not measured) are influenced by the first two and include the actual and perceived confidence and competence in the CHWs' ability to carry out their tasks within the RHIS (Aqil et al., 2009). Together, these inputs affect the model's processes (collection, transmission, processing, analysis and use of ***good quality data***), which in turn contribute to the outputs (patient and program management, monitoring and evaluation) and subsequently outcomes (coverage, utilization, equity and quality of services) and impact (or the health system goals such as reduction in under-five (U5) mortality).

More specifically, I will examine the quality of CHW data for the purposes of program monitoring and evaluation (M&E), and focus on the organizational factors that might influence data quality. This includes level of program support, supervision and training of CHWs, time spent as a CHW, and CHW sociodemographic characteristics that reflect selection criteria, among others (see Chapter 3 for full list). Other factors (technical and behavioral), while important and contributory, are outside the scope of this dissertation.

Similarly, while I describe all of the dimensions of data quality in Table 1 below, I will restrict the outcomes for this dissertation to accuracy for Aim 1, reliability for Aim 2, and accuracy in the household register and reliability in the village reports for Aim 3. Similar studies assessing data quality at either the facility or community level use accuracy, completeness or reliability as their main outcome measures (Admon et al., 2013; Helleringer et al., 2010; Mahmood et al., 2010; Makombe et al., 2008; Mate et al., 2009; Otieno et al., 2011; Stewart et al., 2001). However, the measures of accuracy used in these evaluations also include reliability. When data are compared to a primary data source, that itself is not verified, and if they match, it may not reflect true validity, but rather reliability (consistency across data sources, not considering 'true' value).

Figure 1. Conceptual framework



The following table outlines criteria of assessing health information systems and data quality from two main sources (the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund) and Health Metrics Network (HMN). In the third column, are my proposed criteria based on feasibility of the routine assessment of data quality in Rwanda.

Table 1. Data quality dimensions

Dimension of quality / Source	GFATM data quality audit tool (The Global Fund, 2008)	HMN assessment of national indicator data quality (WHO, 2008a)	Proposed adaptation for research
Data collection method		Sometimes there is only one gold-standard data-collection method for a given indicator; more often, however, different sources can be used	N/A

Dimension of quality / Source	**GFATM data quality audit tool (The Global Fund, 2008)**	**HMN assessment of national indicator data quality (WHO, 2008a)**	**Proposed adaptation for research**
Accuracy [HMN: representa-tiveness]	Also known as validity. Accurate data are considered correct: the data measure what they are intended to measure. Accurate data minimize errors (e.g., recording or interviewer bias, transcription error, sampling error) to a point of being negligible.	The extent to which data adequately represent the population and relevant subpopulations	Accurate data are considered correct: the data measure what they are intended to measure. The data accurately reflects the actual situation (e.g. if a child has a cough, this is recorded rather than the child has diarrhea). Data are aggregated and entered correctly (e.g. number of children visited is per unique child not per case of illness (error in following protocol); total females + total males ≠ total (error in addition); number children U5 incorrectly entered in box for number women 15-49 (error in transcription). Accurate data minimize these errors to a point of being negligible. *MEASUREMENT* By indicator, define parameters with which data can be determined accurate. For household register only, verified through direct observation. E.g. woman 15-49 on family planning by type should also be exact (for the most part, values should be exactly as observed either through interview or directly verifying information on patient-held cards). NB. representativeness of the value of the actual population may also be assessed through data triangulation

Dimension of quality / Source	**GFATM data quality audit tool (The Global Fund, 2008)**	**HMN assessment of national indicator data quality (WHO, 2008a)**	**Proposed adaptation for research**
Reliability [HMN: consistency]	The data generated by a program's information system are based on protocols and procedures that do not change according to who is using them and when or how often they are used. The data are reliable because they are measured and collected consistently.	The internal consistency of data within a dataset as well as consistency between datasets and over time; and the extent to which revisions follow a regular, well-established and transparent schedule and process	The data are reliable if they are measured and collected consistently. *MEASUREMENT* Data from the village monthly report match iCCM register tallies exactly (accuracy in data aggregation).
Precision [HMN: disaggregation]	This means that the data have sufficient detail. For example, an indicator requires the number of individuals who received HIV counseling & testing and received their test results, by sex of the individual. An information system lacks precision if it is not designed to record the sex of the individual who received counseling and testing.	The availability of statistics stratified by sex, age, socioeconomic status, major geographical or administrative region and ethnicity, as appropriate	N/A

Dimension of quality / Source	GFATM data quality audit tool (The Global Fund, 2008)	HMN assessment of national indicator data quality (WHO, 2008a)	Proposed adaptation for research
Completeness	Completeness means that an information system from which the results are derived is appropriately inclusive: it represents the *complete* list of eligible persons or units and not just a fraction of the list.		Completeness means that there is a value recorded when there should be one, or no missing data. *MEASUREMENT* There is a value recorded where there should be [i.e. it is not left blank]. However, due to the performance-based financing mechanism that rewards CHW cooperatives on the basis of complete reporting (close to 100%), this will *not* be measured for the report; completeness was not measured separately as incomplete report or household register data were necessarily discordant with the source data (unless also missing).
Periodicity		The frequency with which an indicator is measured	N/A
Timeliness	Data are timely when they are up-to-date (current), and when the information is available on time. Timeliness is affected by: (1) the rate at which the program's information system is updated; (2) the rate of change of actual program activities; and (3) when the information is actually used or required.	The period between data collection and its availability to a higher level, or its publication	*Data are timely when they are up-to-date (current), and when the information is available on time per standard operating procedures. *MEASUREMENT* The village monthly report is handed in within 3 days of the end of the month and includes all children seen in the past month as logged in the iCCM register (and sick child forms); however, due to the performance-based financing mechanism that rewards CHW cooperatives on the basis of timely reporting (close to 100%), this will *not* be measured for the report; the household register is completed during the household visit and on a monthly basis according to the visit log.

Dimension of quality / Source	GFATM data quality audit tool (The Global Fund, 2008)	HMN assessment of national indicator data quality (WHO, 2008a)	Proposed adaptation for research
Integrity	Data have integrity when the system used to generate them is protected from deliberate bias or manipulation for political or personal reasons.		Data have integrity when the system used to generate them is protected from deliberate bias or manipulation for political or personal reasons. *MEASUREMENT* This will be reflected in accuracy, but otherwise difficult to measure – N/A
Confidentiality [HMN: plus data security and accessibility]	Confidentiality means that clients are assured that their data will be maintained according to national and/or international standards for data. This means that personal data are not disclosed inappropriately, and that data in hard copy and electronic form are treated with appropriate levels of security (e.g. kept in locked cabinets and in password protected files).	The extent to which practices are in accordance with guidelines and other established standards for storage, backup, transport of information (especially over the Internet) and retrieval.	*Confidentiality means that clients are assured that their data will be maintained according to national and/or international standards for data. This means that personal data are not disclosed inappropriately, and that data in hard copy and electronic form are treated with appropriate levels of security (e.g. kept in locked cabinets and in password protected files). *MEASUREMENT* CHW monitoring tools are kept in locked, wooden box per self-report. Measurement will only include household registers.
Adjustment methods		The extent to which crude data are adjusted in order to take into account bias and missing values. Specifically refers to adjustments, data transformation and analysis methods that follow sound and transparent statistical procedures.	N/A

*Timeliness and confidentiality, while measured during the household register data quality assessment, are included only as independent variables

1.3 Organization of the dissertation

This dissertation is organized in manuscript format. Chapter two presents background information to frame the research, including: literature relevant to CHWs as health care providers, including for community case management of childhood illnesses; how CHWs and community health information fit into broader health systems strengthening frameworks and M&E and routine health information systems; using CHWs for M&E; the issues around, methods and frameworks to examine data quality; the specific study settings in Rwanda; and finally, the contribution of this dissertation to public health policy.

Chapter three describes the different data sources, independent and dependent variables and sampling methodology used for data collection.

Chapter four is a manuscript that describes the measurement of accuracy of CHW data.

Chapter five is a manuscript that describes the measurement of reliability of CHW data.

Chapter six is a manuscript that describes the factors associated with reliability and validity of CHW data.

Chapter seven presents conclusions across manuscripts, strengths and limitations and recommendations for future research.

Chapter eight describes policy recommendations that come from the study.

Chapter nine includes all references for the dissertation.

Chapter ten includes all appendices including all data collection instruments and the toolkit.

Chapter 2. Relevant literature and study setting

2.1 Community health workers as health care providers

Community health workers (CHW) encompass a broad range of lay health workers who generally receive some degree of job-related training, though no formal professional or paraprofessional education. The variety of services they may provide and their title differ by country and program, but usually fall within the health sector. CHWs therefore often serve as a link between health facilities and the communities in which they work. Other issues such as how they are selected, trained, reimbursed, motivated and supervised also vary across programs, though they are frequently vetted by the communities that they represent and serve (Lehmann et al., 2007; Lewin et al., 2010; Perry et al., 2012).

Historically, CHWs have been used to deliver important health services at the household and community levels around the world for decades, including to help achieve "health for all" through primary health care (Berman et al., 1987; WHO, 1978) and more recently to address the health-related MDGs to fight HIV/AIDS, malaria and TB and reduce child and maternal mortality (Bhutta et al., 2005; de Sousa et al., 2012; Edward et al., 2007; Hafeez et al., 2011; Haines et al., 2007; Lehmann et al., 2007; Perry et al., 2012; Prata et al., 2012; Schneider et al., 2010; United Nations Statistics Division, 2012a; WHO et al., 2010; WHO/UNICEF, 2004a, 2004b; Young et al., 2012). The goals of such programs include increasing access to care by removing barriers of distance and costs, identifying and treating illness earlier, and monitoring uptake of health programs.

Furthermore, with the current global focus on universal health coverage beyond the MDGs and post-2015, CHW programs have become key in addressing the shortage of human resources in the health sector that has been exacerbated by the HIV/AIDS epidemic (Bhutta et al., 2010b; CHW Technical Taskforce, 2013; Global Health Workforce Alliance, 2012; Liu et al., 2011; Perry et al., 2012; United Nations, 2013).

Consequently, CHWs are providing important services such as: adherence monitoring in HIV/AIDS and TB programs (Cavalcante et al., 2007; Clarke et al., 2005; Farmer et al., 2001; Franke et al., 2013; Munoz et al., 2010; Shin et al., 2004; van den Boogaard et al., 2009; Wandwalo et al., 2004; Zvavamwe et al., 2009); integrated community case management (iCCM) of malaria, diarrhea and pneumonia (de Sousa et al., 2012; George et al., 2009; George et al., 2012b; Lainez et al., 2012); provision of injectable contraceptives (Brunie et al., 2011; Hoke et al., 2012; Krueger et al., 2011; Malarcher et al., 2011; Prata et al., 2011; Stanback et al., 2010), misoprostol for postpartum hemorrhage (Derman et al., 2006; Prata et al., 2012; Smith et al., 2013) and antibiotics for neonatal sepsis (Bang et al., 2005; Bhutta et al., 2009; Coffey et al., 2012; Khanal et al., 2011); and a variety of preventive and behavior change activities at the community level.

In addition to local, small-scale CHW initiatives, countries have also implemented nation-wide programs to carry out some of these activities, which most recently include Lady Health Workers in Pakistan (Hafeez et al., 2011; Oxford Policy Management, 2009), Health Extension Workers in Ethiopia (Banteyerga, 2011), Health Surveillance

Assistants in Malawi (Gilroy et al., 2012), and multi-disciplinary and maternal health CHWs in Rwanda (Mugeni, 2011), among others. CHWs in all four of these national programs carry out iCCM as part of their scope of work.

Integrated community case management (iCCM)

In 2004, WHO and the United Nations Children's Fund (UNICEF) issued joint statements on the effectiveness of the management of pneumonia and acute diarrhea in the community (WHO/UNICEF, 2004a, 2004b). More recently, they have given a joint statement on the use of iCCM as a strategy for achieving equitable access to critical U5 health services to address all three of the big childhood killers: pneumonia, diarrhea *and* malaria (WHO/UNICEF, 2012; Young et al., 2012). It is currently being implemented mainly in sub-Saharan Africa but also parts of Latin America and Asia and involves the training, support and supply of CHWs to assess, diagnose and treat these three diseases and identify severe malnutrition (George et al., 2012a; WHO/UNICEF, 2012). The statement contains benchmarks proposed by an interagency taskforce on using a health systems approach to implementing iCCM (McGorman et al., 2012). These benchmarks correspond to WHO's building blocks for health systems strengthening as outlined below (WHO, 2007) and include "monitoring and evaluation and health information systems." More specifically, this benchmark calls for: a monitoring framework for all components of iCCM including indicators; standardized data collection and reporting tools; training of CHWs, supervisors and M&E staff on the framework and tools; and a research agenda to inform scale-up and sustainability (McGorman et al., 2012).

2.2 Health systems strengthening

WHO has developed a Framework for Action to strengthen health systems, founded in part on the principles for 'primary health care for all' as laid out in the *Declaration of Alma Ata* (WHO, 1978). It describes six discrete building blocks that make up a health system and help define health systems strengthening (WHO, 2007). These are based on the functions described in the 2000 World Health Report (WHO, 2000).

The six building blocks include (WHO, 2007):

1. **Good health services** ensuring delivery of effective, safe, quality personal and non-personal health interventions to those who need them, when and where needed, with minimum waste of resources.
2. A **well-performing health workforce** that is responsive, fair and efficient to achieve the best health outcomes possible, given available resources and circumstances (sufficient, fairly distributed, competent, responsive and productive staff).
3. A **well-functioning health information system** to ensure production, analysis, dissemination and use of reliable and timely information on health determinants, health system performance and health status.
4. **Equitable access to essential medical products, vaccines and technologies** of assured quality, safety, efficacy and cost-effectiveness, and their scientifically sound and cost-effective use.
5. A **good health financing system** to raise adequate funds for health in ways that ensure people can use needed services, are protected from financial catastrophe or

impoverishment associated with having to pay for them, and providing incentives for providers and users to be efficient.

6. **Leadership and governance** ensuring strategic policy frameworks exist and are combined with effective oversight, coalition-building, regulation, attention to system design and accountability.

A well-performing health workforce and well-functioning health information system -- at the community level

The focus of this dissertation is on a well-functioning community health information system (HIS) that relies in part on a well-performing community health workforce. While the use of CHWs to help reach the MDGs and universal health coverage has been established, measuring progress towards these goals necessitates data from all levels of the HIS, including routine health information, and more specifically, data collected and reported at the community level. In part as a response to this need, the Health Metrics Network, a global partnership based at WHO, was established in 2005 in order to improve the availability, quality and use of timely and accurate health information for evidence-based decision-making by helping countries and partners strengthen their health information systems (WHO, 2008b).

This important health information is collected through the monitoring and evaluation of programs at all levels.

2.3 Monitoring and evaluation

Given the potentially great contributions to improving morbidity and mortality in the communities they serve, monitoring activities carried out by the CHWs and evaluation of these activities can be incredibly important.

Monitoring is the routine tracking of key elements of program or project performance, through record-keeping, regular reporting and surveillance systems as well as health facility observation and client surveys (The Global Fund, 2009). Examples of monitoring tools may include client cards, registers and reports.

While there has been some debate about the relative relevance and quality of routine health information in the broader HIS, Aqil et al. (2009) argue that there is no substitute for this type of data when monitoring progress towards many process, output and some short-term outcome indicators within health programs.

Data collection takes place at different levels in a community HIS often starting from the CHW. CHWs record information about various components of the activities they carry out in the community. Community- or facility-based CHW supervisors may have supervision checklists which may be submitted, or collate information received from CHWs on a regular basis. Health facilities may in turn collect and report on CHW activities to the district or national level. Recently, mobile phone technologies have been developed to facilitate data collection and reporting by CHWs in several countries, including Rwanda (CHW Technical Taskforce, 2013; Källander et al., 2013; Mechael et al., 2010; Qiang et al., 2011).

CHWs can use monitoring tools to adhere to guideline protocols, follow up clients, manage drugs and other supplies, and understand client load. Use of such tools may be associated with greater CHW adherence to guidelines as Rowe et al. (2007a) found in their study in Kenya. Monitoring CHW activities allows supervisors and program managers to determine what services are being provided and how they are provided. Program managers and funders can likewise use the information to look at quality of care, coverage and equity of CHW services.

Evaluation is the periodic assessment of the change in targeted results that can be attributed to the program or project intervention. Evaluation attempts to link a particular output or outcome directly to an intervention after a period of time has passed (The Global Fund, 2009).

Ideally, routine monitoring information can also contribute to broader evaluations of a CHW intervention or program. This has been done in the context of both the grey (Greer et al., 2004) and published scientific literature (Gilroy et al., 2012; Kelly et al., 2001; Lainez et al., 2012; Rowe et al., 2007a; Rowe et al., 2007b). Often, these evaluations either supplement CHW monitoring information with, or only use, other data sources including: household surveys, case scenarios and other forms of knowledge-based testing, exit interviews, direct observation, focus group discussions and in-depth interviews of caregivers, facility-based workers and CHWs. However, these tend to be more timeconsuming and costly. Therefore, the ability to use routinely generated CHW data for program management and evaluation means the information collected and reported must be adequately timely, accurate and reliable. This in turn could contribute to considerable cost savings if use of alternative data sources is minimized or altogether unnecessary.

However, while monitoring and evaluation are basic elements in the management of CHW programs, neither has necessarily been adequately studied (Lehmann et al., 2007; WHO study group on CHWs, 1989).

2.4 Role of CHWs in monitoring coverage and quality of services

In their roles as health service delivery workers, CHWs generally collect and transmit data on their activities. Due to their broad reach and respect in their communities, programs and researchers have also used CHWs as more formal data collectors. For example, in humanitarian emergency settings, organizations may use CHWs to collect demographic, mortality and anthropometric data as they may provide greater acceptance for and address local barriers to collecting surveillance data (Bowden et al., 2012; Caleo et al., 2012).

In research settings such as community trials, CHWs with a minimum level of education and who receive adequate training and supervision, can function as reliable data collectors (Shah et al., 2010).

2.5 Data quality

In a presentation on assessing for data quality, MEASURE Evaluation note eight functional components of an M&E system that are necessary for data quality. These include: 1) M&E capabilities, roles and responsibilities; 2) training; 3) data reporting requirements; 4) indicator definitions; 5) data collection and reporting forms and tools; 6) data management processes; 7) data quality mechanisms and controls; and 8) links with the national reporting system (MEASURE Evaluation, 2007; The Global Fund et al., 2008).

Within any HIS, M&E activities have the potential to generate a large quantity of data to be used for either research or decision-making processes. In order for data to be useful, at the very least, they must accurately reflect what is being monitored or evaluated, and additionally should be timely and relevant (see Table 1 for other possible measures of data quality). If not, program managers and other stakeholders risk making ill-informed decisions, recommendations or assertions that may result in inefficiencies in allocating financial or other resources and other unintended (negative) consequences. However, data quality at all levels of the HIS may be of questionable quality.

Facility-based data quality

For example, studies carried out in sub-Saharan African countries have shown that data used for program management or evaluation taken from facility-based information systems – whether paper-based or electronic -- can be of sub-optimal quality (Forster et al., 2008; Garrib et al., 2008; Makombe et al., 2008; Maokola et al., 2011; Mate et al., 2009; Mavimbe et al., 2005; Ndira et al., 2008; Rowe et al., 2009).

An evaluation of data quality in the South African district HIS for a large public health program showed that six selected data elements were complete about half the time and reliable (within 10% of externally verified numbers) only 12.8% of the time (Mate et al., 2009). The authors pinpointed incorrect tallying from clinic registers to monthly report forms as the cause of the errors and concluded that the data were not of adequate quality to track process or outcome indicators for this national program.

Community-based data quality

Unlike many facility-based information systems, a community HIS may not be standardized or highly scrutinized. Depending on how participatory the development of the system was, CHWs may not understand what data they are collecting or why, to the extent that they may be missing opportunities to use the data to facilitate managing and performing their activities.

For example, Debay et al. (2003) make a distinction between community-focused and community-based health information systems by level of community engagement. The community supplies data in the former, and additionally is involved in planning and decision-making in the latter (Debay et al., 2003). The level of participation in the development of a community HIS will inevitably affect whether and how data are used by CHWs.

Furthermore, community-level data may not be complete, and the overall quality of data recorded can be variable, which may then affect interpretation of program information being collected and reported by CHWs. Data transcription and collation between the different (community and facility) levels may add to the already questionable data quality.

To date, however, few studies have assessed the quality of data collected and reported by CHWs.

One such study from Pakistan found only 47.5% of monthly reports submitted by community-based Lady Health Workers to be accurate; the percentage varied depending on the indicator (e.g. deaths were more accurately reported than immunization status and births) (Mahmood et al., 2010). Similarly, in Neno, Malawi, Admon et al. (2013) found 25-44% of CHW reports pre-intervention to be unreliable depending on the indicator. Another reliability study in Kisumu, Kenya found CHW data of varying quality depending on activity area; for example, latrine and antenatal care use were more reliable than immunization coverage indicators (Otieno et al., 2011). Helleringer et al. (2010) found both over- and under-reporting to be common in an operational study looking at the quality of CHW data in the upper east region of Ghana.

Data are often used regardless of their actual or perceived quality. The degree to which data must be accurate and complete depends on how they will be used. For example, Seguy et al. (2006) found that routine data collected in the national prevention of mother-to-child transmission of HIV (PMTCT) program were, among other things, not accurate enough to use to estimate HIV prevalence in Kenya. Similarly, Otieno et al. (2011) found that while CHW-collected data were 90% concordant with well-trained research assistant-collected data, they recommended they were only useful at the local level as their precision was not high enough for national level decision-making. In Malawi, Makombe et al. (2008) found that due to a total of 12% underreporting by sites of numbers of HIV patients on first-line drug regimens, this would lead to an underestimation of drug stock orders, and potentially adverse patient outcomes. If, on the other hand, these numbers were reportable as a means of understanding the extent of the scale-up of the HIV treatment program, a 12% discrepancy might be acceptable.

Factors related to data quality

At the facility level, Makombe et al. (2008) found that supervision, presence of a data entry clerk, greater program experience and patient volume were associated with completeness and accuracy of data collected and reported in Malawi's ART program.

Crispin et al. (2012) found that CHW sociodemographic characteristics including age, sex and level of education were associated with 'good' or 'poor' record-keeping in Busia District, Kenya.

Anecdotally, authors found that <50% accuracy in monthly reports in the national Lady Health Workers program in Pakistan to be attributed to weak supervision and inappropriate and numerous data collection instruments (Mahmood et al., 2010). In another study in Ghana where misreporting was common, health center staff shortages during community outreach were believed to be associated with under-reporting (final results are forthcoming) (Helleringer et al., 2010). In Malawi, discussions with stakeholders revealed that competing Ministry of Health demands and inadequate time, training and tools for large-scale data aggregation contributed to poor data quality (Admon et al., 2013).

However, more formal studies of factors related to CHW data quality have not been carried out to date.

Frameworks and methodologies for measuring data quality

The assessment of data quality has become an important component of many large-scale initiatives. For example, the Global Alliance for Vaccines and Immunization (GAVI) uses a WHO-validated data quality audit process to assess countries' immunization information systems to determine additional funding support for these programs (Bosch-Capblanch et al., 2009). Similarly, the Global Fund, together with other organizations developed a similar tool to be able to examine and improve quality of routinely reported information by national HIV/AIDS, TB and malaria programs on an annual basis by external auditors, and more regularly by country program staff (The Global Fund, 2008; The Global Fund et al., 2008).

The Global Fund data quality audits and routine data quality assessments are based on a conceptual framework asserting that quality of reported data depends on the underlying data management and reporting systems. These systems require eight functional areas (as laid out above) at the points of service delivery, intermediate data aggregation and final data repository (The Global Fund et al., 2008).

This framework is another, complementary representation of the PRISM one used to structure this dissertation (see Figure 1); it groups the behavioral, organization and technical factors that influence data quality into 'functional areas' addressing not only the health workers responsible for collecting and reporting the data, but everyone involved in the subsequent data aggregation and compilation process at each higher level.

In research settings at the community level, a variety of methods have been used to assess data quality.

In Ghana, Helleringer et al. (2010) looked at completeness and accuracy of CHW-reported maternal and child health data compared with CHW-collected patient register data and patient-held health cards, and carried out direct observation of data entry during visits with caregivers.

In Kenya, Otieno et al. (2011) compared a 10% sample of data collected biannually by CHW with those re-collected by well-trained research assistants using the same data collection tool. The authors then used the test-retest reliability method to assess concordance between measures over time (assuming that if the instrument is reliable, there should be close agreement over repeated tests).

In Pakistan, authors took a stratified simple random sample of four Lady Health Workers' monthly reports and compared them to the registers (reliability) and a sub-set of household interviews (accuracy). Accuracy was deemed unsatisfactory if <60% of reports were concordant; satisfactory if 60-70%; and good if ≥80% of reports were in agreement (Mahmood et al., 2010).

Finally, in a study from Malawi, authors used Lot Quality Assurance Sampling (LQAS) to classify CHW reports within a cluster of health posts as having 'high' data quality (≥90% agreement with household reports) and 'low' data quality (≤70% agreement). 'Agreement' was defined as having a value within 10% of the household-reported one for any given indicator (Admon et al., 2013).

However, data collection tools were not provided for any study, and in most cases the description of the measurement methodology was insufficient, and with the exception of the Malawi study, the assessments were carried out only once.

Finally, there are community-based tools and frameworks that exist for improving, though not necessarily measuring data quality, such as the beta version of the Community-Level Program Information Reporting for HIV/AIDS Programs (CLPIR) (MEASURE Evaluation, 2010), the PRISM framework (described in Chapter 1) (Aqil et al., 2009) and other models relating data use to data quality in both the scientific and grey literature (Braa et al., 2012; Nutley, 2012).

Therefore, while tools exist to assess the quality of facility-based data (Aqil et al., 2009; The Global Fund, 2008), and community-level data may also be included within these, there is no such standardized, routine methodology for specifically measuring CHW data quality either on its own or as part of a broader community-based health information system.

2.6 Study setting

Rwanda

Rwanda is the most densely populated country in sub-Saharan Africa with roughly 10.7 million people living in an area of about 26,000 km^2 (National Institute of Statistics of Rwanda (NISR), 2012; National Institute of Statistics of Rwanda (NISR) et al., 2012). While the country has made considerable strides towards reaching its MDGs, according to the most recent Demographic and Health Survey (DHS) 2010 report, it still has a relatively high U5 mortality rate at 105/81 (rural/urban) per 1,000 live births, and maternal mortality ratio of 487 per 100,000 live births (National Institute of Statistics of Rwanda (NISR) et al., 2012). Malaria, diarrhea and pneumonia account for a large proportion of U5 morbidity and mortality (Liu et al., 2012; Ministry of Health (MoH) [Rwanda], 2008). Among children U5, 4% had acute respiratory illness (ARI) symptoms (proxy for pneumonia) in the two weeks preceding the survey. Of these, only 28% sought advice or treatment from a health facility or provider. Similarly, 16% of U5 children had fever (presumed to be malaria), and of these, 43% sought advice or treatment. Of the 13% who had diarrhea, 37% sought advice or treatment (National Institute of Statistics of Rwanda (NISR) et al., 2012). Further, malnutrition is an underlying factor in about 70% of all U5 illnesses that result in death (Hong et al., 2009).

Health sector strategic plan

The Ministry of Health's (MoH) vision for the Rwandan health sector is to: "continually [improve] the health of the people of Rwanda, through coordinated interventions by all stakeholders at all levels, thereby enhancing the general well-being of the population and contributing to the reduction of poverty."(Government of Rwanda Ministry of Health (MoH), 2009) To that end, the MoH developed and uses its Health sector strategic plan (2009-2012) (HSSP II) to achieve both national (Vision 2020, Economic development and poverty reduction strategy (EDPRS 2008-2012) and Good governance and decentralization policy) and international (MDGs, Africa health strategy 2007-2015, Abuja declaration, Accra accord and Paris declaration) priorities and targets.

The framework comprises three strategic objectives:

1. To improve accessibility to, quality of and demand for maternal and child health, family planning, reproductive health and nutrition services;
2. To consolidate, expand and improve services for the prevention of disease and promotion of health; and

3. To consolidate, expand and improve services for the treatment and control of disease

The three strategic objectives are embedded in seven program areas and corresponding objectives* that guide health sector interventions and that roughly correspond to the six WHO building blocks for strengthening health systems. Additionally, interventions are targeted at three levels: family-oriented community-based services; population-oriented disease prevention services; and individual-oriented clinical services (Government of Rwanda Ministry of Health (MoH), 2009).

Following a recent decentralization process, Rwanda is administratively organized in order of highest to lowest levels: four provinces (plus Kigali), 30 districts, 416 sectors, 2,150 cells and roughly 15,000 *imidugudu* (villages). At the national level, there are three referral hospitals. At the other levels, minimum requirements are for one hospital per district, one health center per sector and one health post per cell. Currently, almost all district hospitals are in place, with health centers following close behind. Health posts are still under construction in most areas (Government of Rwanda Ministry of Health (MoH), 2009).

National community health worker program

In the HSSP II, iCCM is listed as a high level intervention targeted at the first level –

* 1. Institutional capacity; 2. human resources for health; 3. health sector financing; 4. geographical accessibility; 5. drugs, vaccines and consumables; 6. quality assurances; and 7. specialized services, national referral hospitals and research capacity.

family-oriented community-based services. It addresses all three strategic objectives. Rwanda's 2008 national community health policy proposes the use of CHWs and specifically, iCCM[**] to reach MDG four (Ministry of Health (MoH) [Rwanda], 2008).

The national CHW program, which now has some 45,000 CHWs, was created in 1995 by the Rwandan Ministry of Health (MoH) in an attempt to provide full coverage of decentralized health services at the village level (Ministry of Health (MoH) [Rwanda], 2008; Mugeni, 2011, 2012). In 2005, the MoH designed a revised comprehensive and integrated CHW system to carry out a range of preventive, curative and promotive services, and is currently in the process of implementing trainings for the two types of CHWs at the village level with the following capacities:

1. *Binôme*. One male and one female CHW to carry out iCCM and other activities (see Appendix 10.2)
2. *Animatrice de santé maternelle* (ASM). One female ASM to carry out activities related to maternal and neonatal health including referral and accompaniment of pregnant women to ante- and post-natal care and delivery.

All CHWs are selected by their communities, should have a minimum level of (primary) education and be within a certain age range. While not formally remunerated, they are organized in and compensated quarterly via sector-level cooperatives, through

[**] In Rwanda, this comprises the assessment, diagnosis, treatment and referral of U5 children with diarrhea, malaria and pneumonia and screening and referral for malnutrition by trained CHWs.

development and income-generating activities. *Binômes* receive 200 Rwandan francs (RWF) (or US$ 0.30) per treatment provided which goes directly into the cooperative fund. In addition, a revised performance-based financing (PBF) system started in 2010 and rewards cooperatives quarterly based on quantity of services provided to the community through indicators taken from the monthly SISCom report (Ministry of Health (MoH)[Rwanda], 2009b) (see Appendix 10.3). This is intended to contribute to the compensation of CHWs.

Community health monitoring and evaluation

For each CHW activity or program, the MoH has developed standardized tools for routine monitoring and reporting comprising the community-based component of the overall HIS (SISCom) (Ministry of Health (MoH)[Rwanda], 2008). CHWs are trained on and use a series of forms, registers and reports to collect and report key information (see Table 2).

These tools come in the form of bound books (versus loose sheets of paper) which allow for several months or even years of use. CHWs are provided with wooden lockboxes where they are to store the tools as well as any supplies in their home when not in use.

Chapter 3 describes in further detail the specific data monitoring and reporting tools that were used for this study.

Community health supervision

There is a tiered system of supervision, starting at the cell level, where one *binôme* is selected among his/her peers to oversee activities for all CHWs in their cell (~10 villages). At the time of research, these *binôme* supervisors did not possess any greater qualifications nor receive any additional training to be supervisors. CHWs are organized and trained out of the health centers, where there are two additional at least secondary level-educated supervisors who oversee the activities of all CHWs in their catchment area. At the district hospital, there is one university-educated supervisor who carries out regular supervision visits to the health centers and to CHWs in the field. At the national level, MoH staff and partner organizations conduct supervision visits to district hospitals, health centers and CHWs on a regular basis (Mugeni, 2011).

Data quality assessments

To date, there have been several assessments of facility-level data quality in Rwanda. Concern Worldwide as part of the Expanded Impact Program (EIP) for child survival conducted a health facility assessment in a sample of facilities in their implementation districts in 2007 that included maintenance of U5 records (69% of facilities kept up-to-date and used records, and 25% of CHWs kept up-to-date records) (Concern Worldwide, 2006).

In 2009, the MoH led an evaluation of the iCCM program including completion of individual sick child forms and registers by CHWs (Ministry of Health (MoH)[Rwanda], 2009a). Though the sample of CHWs was not representative, the report found that 91% of CHWs surveyed 'properly completed' at least 80% of the iCCM register. Further, 82%

of the 946 iCCM sick child encounter forms reviewed were at least 80% 'properly recorded'. It is unclear how 'properly' completed or recorded is defined in this report. However, the most frequently cited missing items included: patient identification, nutrition status, main symptoms and concordance between classification and treatment (Ministry of Health (MoH)[Rwanda], 2009a).

Rwanda has a PBF system for rewarding health facilities for quantity and quality of services provided. As part of this, the country is using a generic adapted version of the Global Fund data quality audit tool for the facility-based health information system in order to verify the quality of reported data (Nkusi, 2010). While the community level PBF system is currently operational, the quality measurements for now only include timely and complete reporting in addition to the quantity of certain services provided. It does not routinely verify data that are reported by CHWs, though there are plans to do so in the future (De Naeyer, 2011; Ministry of Health (MoH)[Rwanda], 2009b; MoH [Rwanda] Community Health Desk, 2013). However, tying financial incentives to timely and complete reporting in theory may lead to facets of improved data quality.

Monthly report data compiled at the health center level are entered electronically at the district level and analyzed quarterly at the national level once they are received (Figure 3). It is only at this point that program managers may notice any discrepancies in the data and contact the relevant district or health center to reconcile information. The district is also responsible for validating and generating quarterly reports for the sector PBF steering committee (health center level) so that it may quantify performance and make disbursements to the CHW cooperatives (MoH [Rwanda], 2009). At any level, verification of data generally happens through phone calls to the relevant entity; however, this process is not standardized, routine or enforced and may happen several months after initial submission of the reports (Data verification thematic working group, 2011).

Partners In Health

Partners In Health (PIH), a non-profit corporation based in Boston, Massachusetts, has been working in Rwanda since 2005, to provide technical, financial and programmatic support to three district hospitals and associated health centers to facilitate and strengthen the implementation of the GoR district health systems strategy and more broadly, the HSSP II (Government of Rwanda Ministry of Health (MoH), 2009). With funding from the Doris Duke Charitable Foundation (DDCF), PIH, with the Rwanda MoH and other institutions have formed the Population Health Implementation Training (PHIT) Partnership designed to examine the impact of the Rwanda MoH model of integrated primary health care, CHWs and health systems strengthening implemented in two districts (Drobac et al., 2013). The proposed research is part of this effort to evaluate the effectiveness of the expanded intervention package including the additional benefits of a comprehensive CHW intervention compared to the national system.

The study setting is southern and northern Kayonza and Kirehe districts, Eastern province, Rwanda. The total catchment area is roughly 540,000 persons. PIH supports the full MoH implementation of the CHW program in southern Kayonza and Kirehe districts, and Appendix 10.4 describes PIH's enhancements to the national system in southern

Kayonza only. In brief, PIH supports additional CHW activities, compensation, M&E, data use, trainings, monitoring and supervision tools and supervisors: there is a dedicated, secondary level-educated supervisor at the cell level (replacing the MoH *binôme* supervisor) and an additional clinical supervisor (community health nurse) at the health center who help oversee the supplemental work of the CHWs in southern Kayonza (Appendix 10.4).

This study focuses exclusively on data collected and reported by *binômes*; however, in southern Kayonza, PIH-supported *binômes'* range of care extends to the entire household, beyond iCCM for children U5 (see Appendix 10.4). Chapter 3 describes the supplemental monitoring and reporting tools being used in southern Kayonza. At the time the study was carried out, another partner, IRC (International Rescue Committee) provided technical and financial support to the CHW program in Kirehe. This included support around M&E, behavior change, training, quality assurance and nutrition in the community (IRC, 2000). EGPAF (Elizabeth Glaser Pediatric AIDS Foundation) supported HIV-related activities in northern Kayonza.

2.7 Contribution to public health policy

This dissertation contributes to public health policy in several ways: generally, to the broader work on CHWs; more specifically through Aims 1, 2 and 3; indirectly through the routine data quality assessment methodology produced by Aims 1 and 2; and finally, to Rwanda-specific programs.

General research on CHWs

Given the growing use of CHWs to address global health priorities, and the numerous reviews looking at the potential effectiveness of CHWs to do so (Bhutta et al., 2010b; George et al., 2012a; Lehmann et al., 2007; Lewin et al., 2010; Perry et al., 2009; Viswanathan et al., 2010), good data on CHW programs are critical to inform such recommendations and research moving forward. However, among these reviewers, Lehmann et al. (2007) note there is scarce research on the monitoring and evaluation of CHW programs, and Perry et al. (2012) report that programs would benefit from operations research during the implementation process in addition to focusing on health outcomes. In addition, to date, the quality of CHW–reported data and their use for driving improvements in quality of community-based care are largely unknown with few exceptions – in any region (Admon et al., 2013; Helleringer et al., 2010; Mahmood et al., 2010; Otieno et al., 2011).

Therefore, this dissertation fills these gaps by addressing an important component of M&E – data quality, and by doing so through the use of operations research to inform program improvements. By providing programs and governments with a routine data quality assessment methodology and some insight into one country's experience with CHW data quality (accuracy and reliability), this dissertation may contribute to the more widespread assessment, improvement and effective use of CHW-generated data.

iCCM program monitoring

In a recent UNICEF review of CCM programs in sub-Saharan Africa, MoH officials rate ‘monitoring’ as one of the top three concerns of implementing such a program (George et al., 2012a).

Aim 2 of this study specifically assesses iCCM program data quality. Given the recent WHO/UNICEF joint statement promoting the iCCM strategy as a way to reduce childhood mortality, more and more countries will be implementing it, and will need to address monitoring concerns (as noted above) (WHO/UNICEF, 2012). This dissertation provides results and a framework to do so based on a country-specific context.

Household level data collection and evaluation

Routine CHW data have been used for more than just patient and program monitoring and management; in some settings, they have contributed to more formal evaluations and may reliably measure contributions of CHWs to important indicators on quality of care, coverage, utilization and equity, thereby removing the need for more costly alternative data sources (Shah et al., 2010).

Decision-making based on evaluation findings using data of questionable quality can result in poor program management or misallocation of funds. It is therefore important to understand whether and if CHWs are able to produce data of adequate quality not just to monitor a program, but also to evaluate it.

Aim 1 addresses the accuracy of household-level data collection by CHWs. Unlike the aggregated data in Aim 2, these data can be entered and used directly from the source providing valuable information at a population level on basic sociodemographic characteristics and target population health indicators over time to be used by governments and researchers for such evaluations.

Factors related to CHW data quality

There are even fewer studies looking at the factors related to CHW data quality. Aim 3 systematically links CHW and program factors with data quality outcomes accuracy and reliability, pointing to specific issues that CHW program managers may want to consider when training or selecting CHWs and designing a community health information system.

Routine methodologies to assess data quality

Validated methodologies and tools exist to assess data quality at the facility level, and broader health information systems that may include the community level. However, there are no tools specific to the assessment of community-level data quality.

An indirect product of this dissertation is the development of a routine, data quality assessment methodology that can be used by program supervisors in the field. The first step to being able to assess and monitor data quality is to have an efficient and effective means of measuring it. If program managers are to use CHW-generated data to inform decision-making, a simple and practical tool to ensure the data they are using is of sufficient quality is critical.

Rwanda-specific policy

The results of this dissertation have specific relevance to the GoR and its CHW program. They will allow the government to routinely monitor, improve and use community health data in the future for their monitoring and evaluation needs, including its iCCM program at all levels. Additionally, as the MoH moves to integrate the household register into the broader SISCom, it will also be important to understand how well these data are collected and how they could be used by the GoR more generally.

Furthermore, in Rwanda the MoH provides PBF to CHW cooperatives on the quantity of certain indicators reported by CHWs. Data quality is routinely assessed at the health facility level. At the community level, data are also required to be timely, complete and correct, but at the time of study, correctness was not being measured or assessed in a standardized way, if at all (De Naeyer, 2011; MoH [Rwanda], 2009). The methods described in this dissertation may contribute to a routine process of evaluating and correctly compensating CHW data accuracy and reliability, and allow the government to understand and address factors related to poor data quality.

In sum, this dissertation will not only measure CHW data quality, but also provide information for action and improvement of poor quality data on a routine basis such as additional training or supervision. It will additionally contribute to global learning about how operational approaches affect CHW data and resulting patient and program management, monitoring and evaluation in Rwanda and other similar settings.

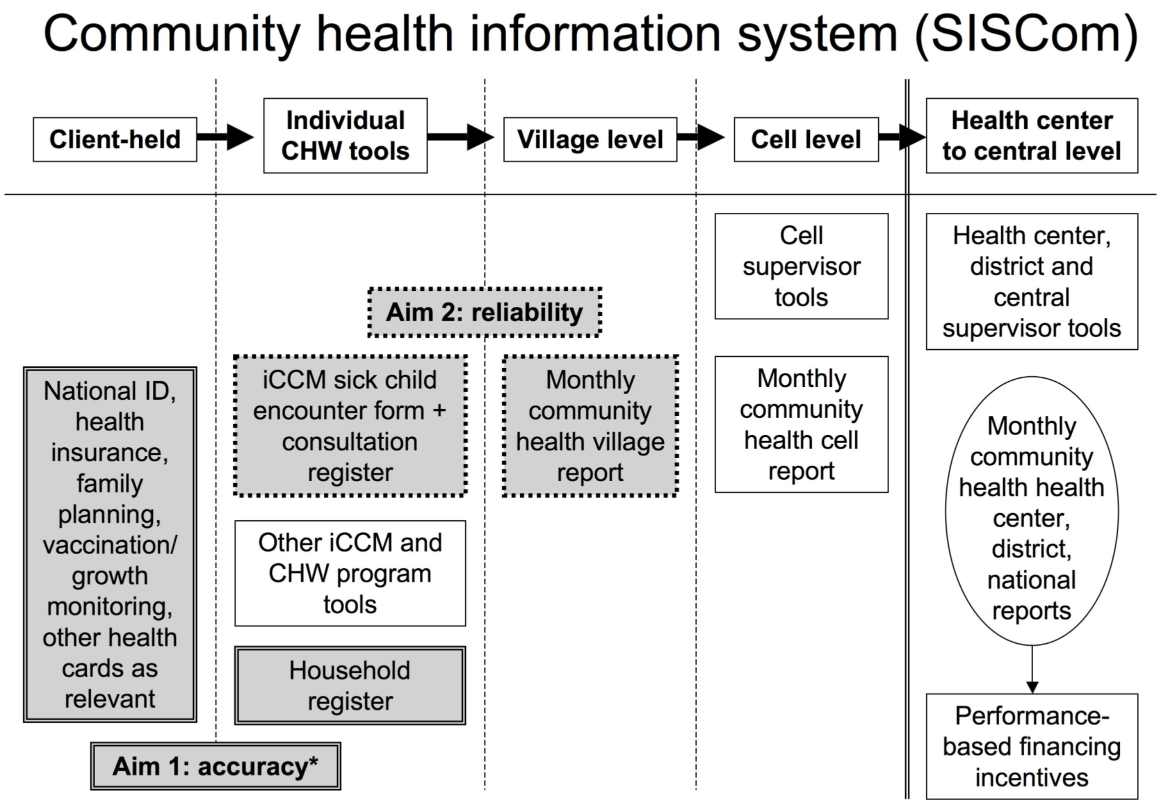
Chapter 3. Data sources

3.1 Introduction to data sources

Aims 1 and 2 of this dissertation assessed the quality of routine community-level data from different CHW monitoring and reporting tools within the national health information system in Rwanda (see Figure 2). In Aim 1, we specifically looked at data within a single national CHW program (iCCM, previously described) comparing numbers tallied from CHW-held consultation registers with village-level monthly report form totals (aggregated by two or more CHWs). In Aim 2, we evaluated the data quality of another CHW-held register that was not program-specific (household register). We compared the information recorded in the household-level register with client-held health and identification cards and interviews. At the time of study, this register had only been implemented in one district (southern Kayonza).

The following figure shows how the CHW tools and their data sources used in Aims 1 and 2 are configured within the overall SISCom.

Figure 2. Aims 1 and 2 presented within SISCom



* Household register data accuracy compared to household member self-report and client-held cards

The following table presents a summary of the data sources and their definitions used in this thesis, and the sections following describe them in more detail.

Table 2. Data sources for Aims 1 and 2 and other CHW program tools

Tool	Purpose	Data quality
Aim 1		
Household register	Household-level data collection tool currently implemented in southern Kayonza only for CHWs to monitor key health information of households in their catchment area on a monthly basis. Includes 13 tables (see Table 4)	Indicators from tables 1, 3, 4 and 9 assessed for **data accuracy**, compared to client-held family planning, vaccination, insurance and national ID cards and household interview
Client-held family planning card	Health facility-provided client-held card logs information on (modern) family planning method used	Used to verify data accuracy from Table 3 of household register (type of family planning)
Client-held vaccination card	Health facility-provided client-held card logs vaccinations received by children under age 5,	Used to verify age of children under 5 in household in table 1

Tool	Purpose	Data quality
	includes child's name and birth date	of household register
Client-held insurance card	Social insurance (mutuelles) card kept by client includes name and birth date – one for each member of the household, adult or child	Used to verify ages of women 15-49 and children under 5 in household in table 1 of household register
Client-held national ID card	Government-provided national ID card to all citizens aged 16 and older includes name and birth date	Used to verify ages of women 15-49 in household in table 1 of household register
Aim 2		
SISCom monthly report	Standardized monthly report including information from all national CHW programs, aggregated at the village level by all CHWs, then cell, health center/sector, district and national levels. Indicators are source of PBF payments into CHW cooperatives	Indicators from section A (iCCM) assessed for **data reliability** compared to iCCM consultation register tallies (and sick children forms in southern Kayonza only)
iCCM sick child encounter form	CHW completes one sick child encounter form per child seen. Includes information on symptoms, assessment, treatment and follow-up	Used to verify tallies in Section A of monthly village report in southern Kayonza district (pilot) only
iCCM consultation register	CHW completes one line per sick child seen. Includes sub-set of information from sick child form on date seen, age, symptoms, assessment, treatment and follow-up	Used to verify tallies in Section A of monthly village report in all three districts
Other CHW tools		
iCCM stock cards	One per drug/supply kept up to date and used to complete Section H in monthly report	
U5 growth monitoring register	Each month, all children U5 are measured for mid-upper arm circumference (MUAC) and weight-for-age at the village level. The register also includes Vitamin A, mebendazole and breastfeeding information	
Referral / Counter-referral form	All CHW programs use the same form to refer clients to the health center. The health center in turn should complete the counter-referral form and return it to the referring CHW	
Family planning clients register	CHWs record information on family planning method received (not yet country-wide)	
Pregnant woman and newborn follow-up form	Each pregnant woman and their newborn(s) are followed using a single form	
Pregnant woman and newborn register	A subset of information for each pregnant woman and their newborn is transferred from the follow-up form to one line of the register. These data are then aggregated at the end of the month into Section D of the monthly report	
Women 15-49 years register	ASMs update quarterly a list of all women aged 15-49 years in their village (to subsequently monitor for pregnancy)	
Monthly CHW, village, cell, health center report, Page 2 (PIH only)	Additional page to monthly report filled by PIH CHWs then aggregated at village, cell and health center levels	

Tool	Purpose	Data quality
Supervision tools		
iCCM cell supervision form	Cell-level supervisors should visit all *binômes* in their catchment area monthly to support and verify iCCM activities	
iCCM health center supervision form	Health center-level supervisors should visit all *binômes* in their catchment area quarterly to support and verify iCCM activities	
General cell supervision form (PIH only)	Cell-level supervisors should visit all *binômes* and ASMs in their catchment area monthly to support and verify all relevant activities	
General health center supervision form (PIH only)	Health center-level supervisors should visit all *binômes* and ASMs in their catchment area quarterly to support and verify all relevant activities	

3.2 Rwanda national data

National health management information system

Rwanda has a national health management information system (système d'information sanitaire or SIS) which is based on a minimum set of key indicators and standardized data collection and reporting tools (MoH [Rwanda], 2013). The electronic version of the system has recently been migrated to a new web-based platform: the District Health Information System 2 (DHIS-2). SISCom is the community health component of this broader system.

SISCom (système d'information de la santé communautaire)

Each community health program has its own set of forms and registers (see Table 2), including for iCCM which comprises:

1. a sick child encounter form (Appendix 10.5)
2. a consultation register (Appendix 10.6)
3. a generic referral/counter-referral form
4. stock cards for each medicine and supply

5. job aids in the form of laminated diagnosis and treatment algorithms for malaria, diarrhea and pneumonia

The monthly SISCom report (Appendix 10.7) including key information for all community health programs, is compiled at the village level by all CHWs, and then aggregated by the supervisors at each administrative level -- the cell, health center/sector and district -- whereupon electronic entry of the reports into DHIS-2 allows for transmission to the national level (see Figure 3). Quarterly analysis of the data including validation takes place at the national level. Similarly, district supervisors and sector-level cooperative committees are also required to validate, analyze and provide feedback to lower levels on monthly report data received (MoH [Rwanda], 2009). At time of research, there were plans for electronic entry at the health center level, and mobile phone entry by CHWs at the village level (after completion of the paper form).

Figure 3. Flow of data in the iCCM program within SISCom (Aim 2)

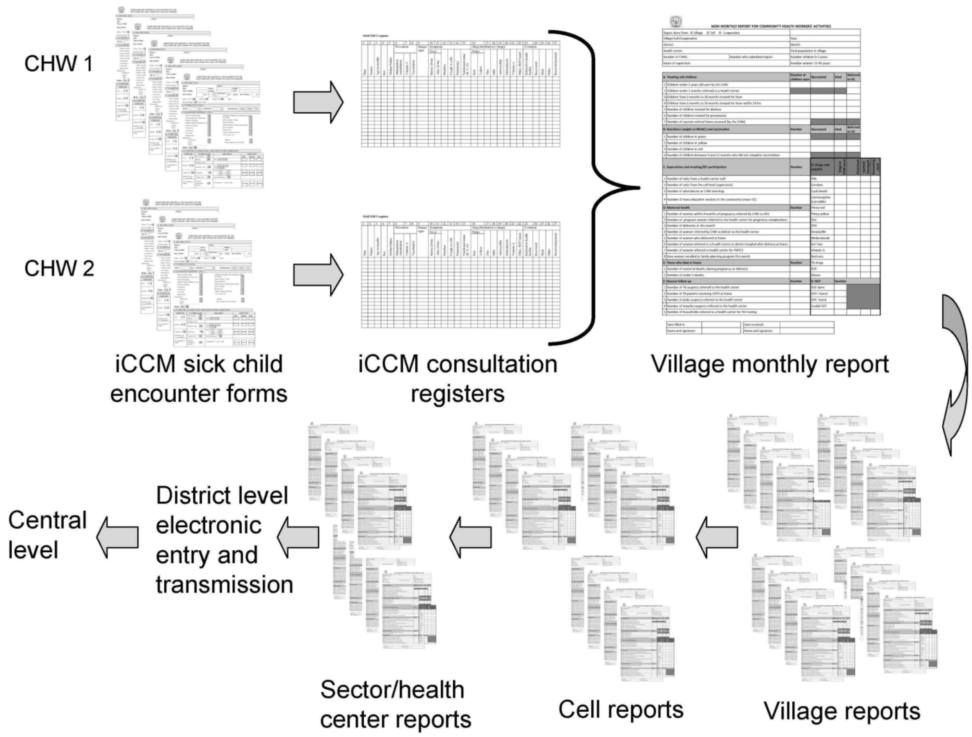


Table 2 presents the tools in use at the time of research, including those used only in PIH-supported districts (see section 3.2); however, as the national community health program is quite dynamic, new tools are continuously in development for other CHW activities. These tools are not included here.

Aim 2 of this study compares data reported in the monthly village-level SISCom report section A (Appendix 10.7) with the iCCM consultation registers (Appendix 10.6) and iCCM sick child encounter forms (Appendix 10.5) (see Figure 2). *Binômes* are responsible for completing an encounter form for each sick child they see. The form provides an algorithm that guides the CHWs through the assessment, diagnosis and treatment or referral of the child's presenting symptoms. It includes a follow-up section to see whether the child's condition improves or worsens and requires further treatment or referral. CHWs transfer a subset of this information to the consultation register (one line per child), and at the end of each month (this varies by health center, but generally takes place from the 25th to 28th of the reporting month to allow for timely aggregation at each subsequent level), tally key indicators from the register to complete the village SISCom report with other CHWs.

3.3 Partners In Health data

Due to the broader mandate of CHWs and their supervisors in southern Kayonza, PIH has supplemented the national system to be able to monitor these additional activities with the following tools (see Table 2): 1) at CHW, cell and health center levels an additional page of key data elements for the monthly report; 2) a household register for *bînomes* to monitor health of household visited on a monthly basis; and 3) more general supervision (checklist) tools for cell and health center level supervisors.

For Aim 1, the household register described in Table 3 (below) was assessed for data accuracy (see Appendix 10.8). *Binômes* in southern Kayonza provide a range of care extending to the entire household, beyond iCCM including monthly household visits. They use a longitudinal community health household register to collect and update key data, including information on basic demographic characteristics of all household members and target populations such as U5 children and women of reproductive age.

The household register was developed and tested by PIH at the request of the MoH for a tool for CHWs to collect routine household-level data over time that could eventually be integrated into SISCom. The tool development process began in 2008 and district-wide implementation took place in October to November, 2011. Based in part on the results of this study, PIH is working with the MoH to adapt and integrate the household register into SISCom.

The household register was designed to be used for the duration of one year by CHWs for all their households (~50) and currently comprises 13 standardized lists to enable: 1) monitoring households and target populations; 2) standardized aggregation and reporting; and 3) CHW supervision at all levels. The lists (see Table 3) include information on household members, children with possible malnutrition, women on family planning methods, pregnant women, tuberculosis suspects, deaths, household visits, meetings, trainings and supervision received. Data from the household registers also fill current SISCom monthly village reporting gaps (at least 10 indicators).

Table 3. Description of household register lists

	List	Description
1	Household list (name, sex, date of birth, insurance status, death)	Line listing of all households with unique household numbers that can be referenced in subsequent lists
2	Children U5 with possible malnutrition status	Complements MoH monthly village-level growth monitoring register (in the process of being rolled out), this list monitors those children with MUAC or weight-for-age zone in yellow (moderate) or red (severe) to ensure follow-up by facility- and community-based programs and monitor improvement of nutritional status
3	Women on family planning methods	Allows for the aggregation of women currently on modern family planning method (condom, pill, injectable, implant, tubal ligation, partner vasectomy or none). Logs method and initiation, discontinuation and re-start dates. Reasons for discontinuation may be recorded in Notes section (see below)
4	Pregnant women	PIH multi-disciplinary CHWs still follow pregnant women (estimated due date, antenatal care visits, actual date and location of delivery, pregnancy outcome), though primary responsibility is to ensure follow-up by ASMs
5	TB suspects (cough > 2 weeks in persons over 5 years)	Monitors case-finding of TB suspects from referral to treatment
6	Persons on accompaniment (excluding TB and HIV)	For CHWs also carrying out accompaniment, PIH requires numbers of persons on accompaniment in report. These include persons in non-communicable disease program, with mental health issues, epilepsy and cancer
7	Persons on accompaniment for TB and HIV	See above – for TB and HIV patients, name is not disclosed.
8	Deaths	Records age, date and location of deaths for SISCom report.
9	Household visit log	Allows CHWs to account for key activity – monthly household visits, and supervisors to ensure they are doing these. Enables aggregation of visits for monthly reporting (Page 2)
10	Meetings attended by the CHW	As above, allows CHWs to account for activities and monthly reporting (and theoretically, compensation)
11	Supervision visit log	Allows CHW to keep track of supervision visits and for monthly reporting purposes. Allows higher level supervisors to ensure lower level supervisors are carrying out routine CHW visits
12	Participation in sensitization and education sessions by CHW	As above, allows CHW to keep track of their activities and for monthly reporting
13	Trainings attended by the CHW	As above, allows CHW to keep track of their activities and for monthly reporting (and theoretically, compensation)
	Notes	
	Accompaniment forms	Nine daily accompaniment forms for TB and HIV patients
	SISCom monthly CHW reports (pages 1 and 2)	Page 1 is an exact copy of the MoH report, generally compiled at village level, but at PIH, at CHW level. Page 2 is a supplementary report including key indicators allowing PIH to track the additional activities carried out by their CHWs (e.g. monthly household visits, accompaniment, etc.)

3.4 *Sampling strategy*

Lot Quality Assurance Sampling (LQAS)

LQAS was originally developed and used to control quality of industrially produced goods in the 1920s, but has since gained popularity in the field of public health due to its somewhat simple and easy to understand sampling and analysis procedures (Dodge et al., 1929; Lwanga et al., 1991; Pagano et al., 2010; Robertson et al., 1997; Robertson et al., 2006; Valadez, 1991). A relatively small sample size is needed to determine whether a 'lot' has reached an acceptable level of quality, coverage, supervision or other outcome. Upper and lower thresholds must be identified as acceptable and unacceptable cutoffs for the outcome (Robertson et al., 2006). In their global review of health care surveys using LQAS, Robertson and Valadez (2006) found a total of 805 conducted in 55 countries, with almost 40% in Africa.

Aims 1 and 2 of this study use LQAS as a sampling and classification strategy specifically for its practical application in public health programs and routine implementation by lower level supervisors.

The table below summarizes the levels of classification and sampling units used with the LQAS methodology in Aims 1 and 2. Lots are cells (Aim 1) or health centers (Aim 2). For Aim 2, as CHWs are trained and supervised at health center level, the assumption is that quality in reporting data may be heterogeneous between health centers but homogeneous within health center catchment areas. While CHWs are also supervised at the cell level, cells have too few CHWs (~20 per cell) and require too large a sample size to be feasible to use as strata for Aim 2. However, due to the lower level unit of sampling for Aim 1, there are a sufficient number of households in a given cell to use it as the lot.

Table 4. LQAS levels of classification and sampling for Aims 1 and 2

Data quality of …	Lot receiving classification	Level of aggregate point estimate	Unit of sampling
Household register (accuracy)	Cell	Health center	Households (per CHW)
Monthly village SISCom report (reliability)	Health center	District	Village

The range of quality of both facility-based and CHW data may provide guidelines, though not absolute standards for determining the thresholds for the LQAS strategy in this study. For example, at the facility level, Makombe et al. (2008) estimated 70% of sites had complete case registration reports, but only 40% had accurate reports (data missing or > five percent difference compared to gold standard). Mate et al. (2009) estimated that 50% of reports were complete and only five to 20% of data were accurate (within +/-10% of expected). At the community level, fewer than half of CHW reports were accurate in Pakistan (Mahmood et al., 2010), but 90% of CHW-collected data were reliable in Kenya (Otieno et al., 2011). Further, as noted in Rwanda's May 2009 iCCM program evaluation, CHWs reported ~80% completeness on average, though there is no real indication of accuracy (Ministry of Health (MoH)[Rwanda], 2009a).

In the end, the thresholds and misclassification parameters and sample sizes for both Aims 1 and 2 were determined through a process of reviewing the existing literature, considering programmatic priorities and expectations as set by the Community Health Department at PIH, and conducting a pilot at a subset of health centers. In Aim 1, the sampling methodology was tested in one health center (Kabarondo) in southern Kayonza due to topography and proximity of households to each other. In Aim 2, the sampling methodology was tested in southern Kayonza (PIH fully-supported) district only using routinely collected data that the MoH shared with PIH through an existing memorandum of understanding (MoU). For each cell lot in Aim 1, a list of CHWs ordered by village and their households was generated for random sampling. For each health center lot in Aim 2, a list of villages ordered by cell was generated for random sampling.

In addition to classification of lots, LQAS allows for point estimates of the aggregation of lots (health center in Aim 1 or district in Aim 2) to be calculated. Confidence intervals are too wide to allow for point estimates of data quality at the cell or health center (lot) level.

Sample for Aim 1

Cluster LQAS (C-LQAS) was used to determine the number of household register entries to assess, and the number of CHWs to sample at the cell level (an administrative unit comprising roughly ten villages). Each cell was classified as having ‘good’ or ‘poor’ data quality, and an aggregate point estimate of data quality was made for each health center. The sample size was calculated per the process described above. The upper threshold was 95% and the lower 75%. The misclassification error was .10 for both probability of misclassifying ‘poor’ as ‘good’ and ‘good’ as ‘poor’. The sample size was based on these parameters in addition to the expected intraclass correlation coefficient (ICC) of 0.15 from existing literature (Gilroy et al., 2004; Rowe et al., 2002) as well as the estimated

ICC from pilot data (from Kabarondo health center) to account for clustering among households within a single CHW's catchment area. Therefore, six CHWs (m) and six households (k) per CHW were sampled for a total of 36 households (n) per cell (see Table 5 below). There are a total of 34 cell supervisor units in southern Kayonza district; therefore, the total number of households sampled was 1,224 in the catchment area of 204 CHWs. Further technical details for C-LQAS have been described by Hedt-Gauthier et al. (2013).

Table 5. Possible sample size calculations given ICC, number of CHWs and households per cell (n=m*k)

Number of CHWs per cell (m)		4		5		6		7		8		9		10	
Number of HHs per CHW (k)		k	d*	k	d	k	d	k	d	k	d	k	d	k	d
Intraclass correlation coefficient (ICC)	0.01	5	3	4	3	5	4	3	3	4	4	3	4	2	3
	0.025	7	4	6	4	5	4	3	3	4	4	3	4	2	3
	0.05	7	4	6	4	5	4	3	3	4	4	3	4	2	3
	0.075	7	4	6	4	5	4	4	4	4	4	3	4	3	4
	0.1	9	5	6	4	5	4	4	4	4	4	3	4	3	4
	0.15	15	8	9	6	6	5	4	4	5	5	3	4	3	4
	0.2	38	19	12	8	9	7	6	6	6	6	4	5	3	4
	0.25	N/A	N/A	35	22	13	10	9	8	7	7	4	5	4	5

*d is the decision rule for n households
N/A would require more than 50 households per CHW

Sample for Aim 2

LQAS was used to determine the number of monthly village-level reports to assess, and the CHW iCCM consultation registers and sick child forms that feed into the reports. These estimates were determined at the health center level and provide classification of health centers as having 'good' data quality or 'poor' data quality, designations which can be used by the program to target quality improvement interventions. In addition, an aggregate point estimate of data quality was made by district (northern and southern Kayonza and Kirehe) -- % village reports classified with ‘good’ data quality. The sample size (n) was calculated per the process described above. The upper threshold of 90% (and above) categorizing ‘good’ data quality, and below 70% categorizing ‘poor’ data quality, with misclassification error (classifying poor data as ‘good’ at the upper threshold and classifying good data as ‘poor’ at the lower threshold) set at .10 (see Appendix 10.9 for technical details). Based on these parameters, there were two possible sample sizes (n) and decision rules (d): 1) for all health centers with < 65 villages, 19 monthly (village) reports were sampled using a decision rule of four; and for all health centers with ≥ 65 villages, 25 monthly reports were sampled using a decision rule of five. All the CHW iCCM registers (and sick child forms in southern Kayonza only) that fed into these reports were analyzed. The decision rule (d) meant if ‘d’ or more reports were of ‘poor’ quality, the entire health center catchment area was categorized as having ‘poor’ data quality.

In order to ensure the accuracy of the LQAS methodology during the pilot, 19 reports from four health center catchment areas were sampled as described above, and in addition, a census (all village reports) was taken of the other four health center catchment areas’ village reports in southern Kayonza for a total of 175 village reports and 477 CHWs (two to five CHWs per village depending on number of households).

In Kirehe, there are 13 health centers, three of which have ≥ 65 villages in their catchment areas. There are two health centers with 15 and 21 villages respectively for which censuses were carried out. Therefore, the total number of village reports was 263, with two CHWs per village for a total sample size of 526 CHWs. In northern Kayonza, there are six health centers, none of which has a catchment area exceeding 65 villages, two of which have fewer than 19 villages (for which a census was taken). The total number of village reports was 100, with two CHWs per village for a total sample of 200 CHWs. The following table details the sample sizes per district.

Table 6. Sample size calculations for Aim 2

District	Northern Kayonza	Southern Kayonza	Kirehe
Number of health centers (lots)	6	8	13
Number of health centers < 25 villages (take all)	2	1	2
Number of health centers 25- 64 villages (take 19)	4	7*	8
Number of health centers ≥ 65 villages (take 25)	0	0	3
Number of villages in sample (actual sample)	100	175 (140)	263 (261)
Number of CHWs in sample (actual sample)	200	477 (380)	526 (522)

*census was taken at three of these health centers during the pilot phase

Sample for Aim 3

The sample for Aim 3 included a total of 204 CHWs from southern Kayonza selected for Aim 1 (factors associated with accuracy); and all CHWs (including those from the census) in southern Kayonza, northern Kayonza and Kirehe (n=1,203) who were selected for Aim 2 (factors associated with reliability).

3.5 Dependent variables

Aim 1

In Aim 1, the outcome of interest was *accuracy* – or exact agreement between the value(s) entered in the household register (at time of household visit) compared to the externally-validated value(s) acquired through household interview or confirmation from client-held health, *mutuelle* (insurance) or identification cards. Indicators from the household register were chosen in consultation with the PIH Community Health Department based on: 1) corresponding data element(s) in the household register and those practically obtainable from client-held cards or household interview; 2) sufficient volume of indicator for non-zero value during the (monthly) reporting period; and 3) importance for MoH and PIH program monitoring and management. These included:

1) the number of children U5 in the household
2) the number of women 15-49 years of age in the household
3) the number of women delivering at home since start of the household register
4) the number of women currently using a modern family planning method
5) the type of modern family planning method(s) used among women in the household
6) composite indicator whereby data are accurate only if all five indicators above are concordant between the household register and the household interview/client-held cards

As indicated above, LQAS classifications were determined at the cell level by indicator, aggregate proportions and 95% confidence intervals (CI) were calculated at the health center level per indicator, and proportion over-reporting with 95% CI, median difference and interquartile range (IQR) were measured by health center and indicator.

Aim 2

In Aim 2, the outcome of interest was *reliability* (accuracy of data aggregation) – or exact agreement between the value entered in the April 2011 monthly village-level SISCom report and the externally-derived tally from the iCCM consultation registers or encounter forms (SK only) per indicator. Three indicators from the iCCM section of the SISCom report were chosen in consultation with the PIH Community Health Department based on: 1) corresponding data element(s) in SISCom report, iCCM register and form; 2) sufficient volume of indicator for non-zero value during the (monthly) reporting period; and 3) importance for program monitoring and management. These included:

1) the total number of sick children under five years seen
2) the number of children 6-59 months who were treated for fever [with antimalarials] within 24 hours [of onset] and were referred to the health center
3) the number of children [2-59 months] who were treated for pneumonia [with amoxicillin] and recovered
4) composite indicator whereby data are reliable only if all three indicators above are concordant between the report and the registers (or forms)

As noted above, LQAS classifications were determined at the health center level by district and indicator, aggregate proportions with 95% CI were calculated at the district level per indicator, and proportion over-reporting with 95% CI, median difference and IQR were measured by district and indicator.

Aim 3

In Aim 3, the outcomes of interest were the composite indicators as defined in Aims 1 and 2 for accuracy and reliability. Accuracy was analyzed at the household level such that an individual CHW had both accurate and inaccurate household-specific data in the same register. On the other hand, while LQAS classifications were determined at the health center level for Aim 2, reliability was analyzed per CHW, such that all CHWs from the same village (and completing the same monthly report) necessarily had the same outcome.

Accuracy

By household, the household register values for all indicators agreed with those tallied from the household interview and client-held cards (Yes/No).

Reliability

By CHW, the monthly village SISCom report values for all indicators agreed with those tallied from the CHW registers (or forms) (Yes/No).

3.6 Independent variables

Table 7 shows the independent variables collected and used for Aim 3. While most come from the CHW questionnaire, one was derived from the data collected in Aim 2 (number of sick children seen in April 2011 as recorded in the iCCM register), and three were collected in Aim 1 (CHW logged household visit for last month in List 9; CHW keeps household register in wooden lockbox; and CHW keeps wooden box locked).

CHW factors

CHW factors were mostly sociodemographic characteristics including: age, sex, civil status, number living children, level of education and primary occupation. Date of birth was used to impute age, when missing. With the exception of age and number of living children, all other variables were categorical.

Other CHW factors included binary yes/no variables for whether the CHW logged a household visit for last month, whether the CHW stored the household register in the wooden box (the program provided), and whether that box was kept locked.

Program factors

Program variables included level program support from partners – which equated to district; sector cooperative committee membership; CHW type (mutually exclusive); number of years as CHW; number households in CHW catchment area – this was originally collected as a continuous variable, but was categorized in the analysis; walking distance from health center; number of sick children seen in April 2011 – this continuous variable was taken directly from data collected for Aim 2 but was categorized in the analysis; number of times cell supervision visit received; duration of last cell supervision visit; number of times and health center supervision received; and duration of last health center supervision visit; training received in the last six and 12 months – CHWs receive specific training and in theory, annual refresher training for iCCM, how to complete the SISCom report, and others.

Table 7. CHW and program factors associated with quality of CHW data

Independent variable	Type of variable	Description
CHW variables		
Age of CHW	Continuous	CHW age at time of survey in years
Sex	Categorical	0=Male 1=Female
Civil status	Categorical	0=Married/ Cohabiting 1=Single 2=Divorced/ Separated 3=Widowed
Number of living children	Continuous	Number of children currently alive at time of survey
Level of education	Categorical	0=Incomplete primary or less 1=Complete primary 2=Incomplete secondary or higher
Primary occupation	Categorical	0=Farmer 1=Other (informal business, teacher, other), none, missing
CHW program variables		
Level of program support/ District	Categorical	0=PIH support (southern Kayonza) 1=No partner support (northern Kayonza) 2=Other partner support (Kirehe)
Membership on sector cooperative committee	Categorical	0=No 1=Yes
Type of CHW	Categorical	0=*Binôme* only 1=Cell coordinator
Number of years as CHW	Continuous	Years in the role of CHW
Number of households in CHW catchment area	Categorical	0=0-35 households 1=36-60 households 2=>60 households
Distance from health center	Continuous	Walking distance in minutes
Number of sick children seen as recorded in register during April 2011	Categorical	0=None 1=1 2=2 3=3 4=4 or more
Number of times received cell-level supervision visit in last month (*binômes* only)	Categorical	0=None 1=1-2 2=>2
Duration of last cell-level supervision visit (*binômes* only)	Categorical	0=No visit 1=<30 minutes 2=30-60 minutes 3=>60 minutes
Number of times received health center-level supervision visit in last quarter	Categorical	0=None 1=1-2 2=>2

Independent variable	Type of variable	Description
Duration of last health center-level supervision visit	Categorical	0=No visit 1=<30 minutes 2=30-60 minutes 3=>60 minutes
CHW training (any; iCCM; monthly report) in the last six months	Categorical	0=No training 1=Any training
CHW training (any; iCCM; monthly report) ever	Categorical	0=No training 1=Any training
Household register only (except Kabarondo health center catchment area)		
CHW logged household visit for last month in List 9	Categorical	0=No 1=Yes
CHW keeps household register in wooden lockbox	Categorical	0=No 1=Yes
CHW keeps wooden box locked	Categorical	0=No 1=Yes

3.7 Data collection and analysis

Aim 1

Table 8 lists the method(s) used to validate the household register indicators. PIH data officers received training on conducting interviews with household members and verifying information through client-held cards.

Table 8. List of indicators for classification of data accuracy with household register definition and confirmation method during household visit in southern Kayonza district

Area	Variable/Indicator	Household register definition	Method of measuring data quality
Under-5 child health	Number of under-5 children	List 1: Child is under-5 by date of birth OR date of birth is blank & U5 box is checked	Direct observation, date of birth confirmed with vaccination or *mutuelle* card, interview with household members
Maternal health	Number of women 15-49 years	List 1: Sex is female & date of birth OR sex or date of birth are blank & woman 15-49 box is checked	Direct observation, date of birth and sex confirmed with national ID or *mutuelle* card, interview with household members
	Number of women delivering at home	List 4: Place delivered is at home/in the	Confirmation of date and place of delivery by

Area	Variable/Indicator	Household register definition	Method of measuring data quality
	since start of household register	community & actual delivery data is after HH register started and before HH visit	interview with household members
Reproductive health	Number of women currently using modern family planning method by type	List 3: Any method is checked and data and woman not discontinued	Interview with household members, method and last appointment date confirmed with family planning card

Household visits were organized through the health center CHW supervisor who alerted the cell supervisor of the activity. PIH data officers directly communicated with the cell supervisor regarding selected CHWs and their households, and visit dates. On the day of the visits, the cell supervisor directed data officers to each CHW's home. The CHWs then directed the data officers to the selected households.

Direct observation visits were conducted by a team of three trained Kinyarwanda-speaking data officers (one per CHW) with the use of a pre-tested data collection and transcription tool (Appendix 10.10). For each key indicator listed above, the data officer assessed accuracy as recorded in the household register during a visit to the household. Firstly, the data officer asked household members pre-determined structured questions regarding numbers of children U5 and women 15-49 years of age, recent delivery and family planning in the household (Appendix 10.10). Secondly, the data officer re-confirmed accuracy by looking at written documentation in relevant client-held cards such as the vaccination and family planning cards or national identification or insurance cards. Thirdly, the data officer followed each CHW to his or her own home to extract data from the household register for the households surveyed using the second half of the data transcription tool (Appendix 10.10). The household register remained with the CHW through the duration of the household interviews and the CHW was asked to remain outside of the place of interview. The student investigator carried out spot quality checks by following each data officer approximately once per week during data collection.

Neither CHWs nor household members were compensated for their time, though cell supervisors were given pre-paid phone cards (1,000 RWF / US$2) to assist with logistics of data collection.

A team of three data officers visited three to six CHWs and their respective households per day each – three in the morning and three in the afternoon. CHWs were alerted at least one day before the designated visit through their cell supervisor. Both cell supervisors and CHWs received as little advance notice as possible of the activity to minimize the potential for changes to be made to the household registers (and therefore bias the results of the data quality assessment). CHWs were given a list of the randomly selected households (unique numbers) to be able to ensure availability during time of data collection. Each household visit lasted approximately 15 minutes or less. Sampled CHWs were required to hand over their household registers for the duration of the data collection process. Data collection took place from May to June 2012. Data were cleaned and analyzed over a period of one month after completion of data entry into a simple Access database (June to July 2012). Data were collected once (assessing the last complete month's data collected) at baseline. Data collection for the pilot in Kabarondo health center was carried out in January, 2012 with data entry and analysis taking place from January-February 2012. The results from the pilot determined the sampling methodology for the rest of the data quality assessment at the rest of the health centers.

Aim 2

Health centers functioned as data collection points. CHWs in the randomly sampled villages were invited to and compensated (2,000-3,000 RWF / US$3.50-5) for coming to the nearest health center with their iCCM registers (and sick child forms in southern Kayonza only) and village reports for one day. CHWs were remunerated immediately after collection of necessary data. CHWs who came to the health center but were not in the sample were compensated in the local currency for their travel (2,000 RWF / US$3.50) to and from the health center.

A team of two to three trained data officers entered all relevant information (see Table 9 below) from iCCM registers (and sick child forms in southern Kayonza only) and the village monthly reports into a pre-tested, paper-based transcription tool (see Appendix 10.11) at the health center, and then into an Access database at the PIH site. The April 2011 SISCom report from each sampled village was verified with entries during the reporting period in each CHW's iCCM register and forms in the village.

Table 9. List of indicators and register definitions used in classification of data reliability comparing monthly reports to registers

Report indicator	Register definition	Form definition
Total number of sick children under 5 years treated	• Date seen in reporting month* • Age in months <60	• Date seen in reporting month* • Age in months <60
Number of cases 6-59 months treated for fever within 24 hours and referred to the health center	• Date seen in reporting month* • Age in months 6-59 • Fever < 24 hours checked • Primo red or yellow box filled or checked • Referred to health facility checked	• Date seen in reporting month* • Age in months 6-59 • Start of illness ≤1 day • Symptoms: Fever=Y OR RDT is positive OR Classification: malaria=Y • Treatment: Primo red or yellow is checked OR Dose given: any box filled • Action: Refer checked OR Evolution: Referred to HC checked
Number of cases [2-59 months] treated for pneumonia and recovered	• Date seen in reporting month* • Age in months 2-59 • Pneumonia checked • Amoxicillin filled or checked • Recovered checked	• Date seen in reporting month* • Age in months 2-59 • Symptoms: cough/cold=Y OR respiratory rate is >50 if < 12 months; >40 if 12-59 months OR • Classification: Pneumonia=Y • Treatment: Any amoxicillin is checked OR Dose given: any box filled • Evolution: Recovered checked

*Reporting month was April, 2011, which, in reality ranged from 23 March – 28 April depending on health center and village due to higher level reporting deadlines

Data collection was carried out for roughly 21-140 CHWs per day per health center. Data officers returned to any health center where CHWs were absent or failed to bring one or more data collection tool(s) at first visit. The date of the second visit was determined in agreement by the community health supervisor at the health center and PIH data officers. A total of approximately six weeks over April 2011 to March 2012 were spent collecting and entering baseline data once across all three districts. Data were cleaned and analyzed over a period of one month from completion of data collection by district. The data collection for the pilot in southern Kayonza took place from April to June, 2011 using routinely collected data shared by the MoH. Data entry and analysis took place from June to September, 2011. The student investigator (TM) carried out parallel data collection in more detail at the same time as the data officers during the pilot to assess accuracy and quality of data officer data. Data collection for Kirehe district was carried out in the latter part of October, 2011 with data entry and analysis taking place from November to December, 2011. Data collection for northern Kayonza took place in March 2012.

Aim 3

During the data collection process in northern Kayonza and Kirehe districts, the same, trained data officers also used a pre-tested, structured questionnaire (Appendix 10.12) to conduct a short interview with each CHW to collect information on program and CHW factors for Aim 3. These data already existed in southern Kayonza district in a database of routinely-collected information at PIH (are covered by the MoU with the MoH), and were collected over the period October 2011 to May 2012. This was carried out with laptops at health centers with electricity, or with paper forms and entered into computers thereafter, during the same time period as data from Aim 2. Table 7 describes the independent variables subsequently used in the analysis from the questionnaire.

3.8 Confidentiality

The current study falls under the broader institutional review board protocol at Partners Healthcare for the study: *Monitoring and Evaluating an integrated Approach to Strengthening Primary Health Care Delivery in 2 districts in rural Rwanda*, which also includes approval by the Rwanda National Ethics Committee.

Aim 1

Identifiers from the household register were limited to village, cell, health center and household numbers – a sequential number assigned by each CHW to all of the households in their catchment area. Household numbers helped identify children U5, women of reproductive age, women currently using a modern family planning method, and women who delivered at home in the last month during the household visit for tallies (without personal identifiers) to determine quality of these data. Moreover, data were classified as ‘good’ or ‘poor’ at the cell, not individual level.

An existing consent form included in each household register is read to all heads of household before the CHW begins collecting household data. This consent form is orally agreed to and signed by the household head in List 1 (Appendix 10.13). The consent form includes collection of data from other authorized PIH personnel, including the data officers. All data officers received locally appropriate training in conducting respectful household visits for data collection.

Aim 2

No patient identifying information was collected from the iCCM sick child encounter form or the consultation register. Unique identification (ID) numbers were assigned to each CHW to link them to the database created as part of Aim 3. Data transcribed from the village monthly report were aggregated and therefore did not contain any individual identifiers.

For Aim 2, CHWs were randomly selected by village from an existing list. As the assessment of data quality was seen as a routine activity being piloted, this was in the normal engagement of CHW activities and their responsibilities. The community health supervisor at each health center was informed through the district hospital, and was responsible for contacting (via telephone) the selected CHWs to inform them of the assessment and to come to the health center on the appointed day with all relevant data collection and reporting tools.

Aim 3

All CHWs were identified by a unique ID number. This number was linked to information including: name (for verification only), village, cell, health center and all other independent variables listed in Table 7. For the purposes of this study, name was not used, and age was imputed from date of birth. Unique ID and village/cell/health center were used for purposes of linking CHW characteristics to data quality (see Aims 1 and 2).

3.9 Regression model

Aim 3

Descriptions of CHW and program factors included proportions with 95% CIs. Analyses were done separately by district and outcome.

For the outcome variable in Aim 1, accuracy was dichotomized as a binary variable where Y= 0 if household data for the composite indicator were not accurate and Y=1 if household data for the composite indicator were accurate based on exact agreement per household (an individual CHW may have had both accurate and inaccurate household level data). For Aim 2, reliability was dichotomized as a binary variable where Y=0 if the composite indicator for the CHW register tallies did not match the village report and Y=1 if the composite indicator for the CHW register tallies did match the village report (all CHWs from one village had the same outcome). For all outcome variables, logistic regression analyses and resulting odds ratios (OR) determined associations between the probability of reliability or accuracy (Pr) and $X_{1\ldots}$CHW or program factors listed in Table 7 using the following formula:

$$\text{Logit}[\Pr(Y=1)] = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\ldots$$

Where,

X_1 = Level of program support

X_2 = Level of supervision

X_3 = Level of training

X_4 = Time spent as CHW

… = Other relevant CHW or program factors, confounders and effect modifiers

Univariate and multivariate logistic regression models were fit separately for each dependent variable (accuracy and reliability) to examine the associations between them and CHW and program factors. The Hosmer-Lemeshow test for goodness-of-fit was used to determine fit of the models. Collinearity was determined by running separate multiple regression analyses to calculate variance inflation factors which were all below 10.

Possible confounders and effect modifiers were examined and accounted for as relevant based on previous study findings including other program factors. Intraclass correlation that may be present between CHWs of the same health center when analyzing data quality of iCCM sick child forms and registers and between households of the same CHW catchment area were accounted for by using generalized estimating equation (GEE) models with robust standard error estimates.

Chapter 4. “Data for program management: an accuracy assessment of community health worker data collected in southern Kayonza, Rwanda” (Manuscript 1)

4.1 Abstract

Background: Community health workers (CHWs) collect and report on information for both routine services provided, as well as specific surveys or research carried out in their communities. Decision-makers utilize this information at all levels of the health system. However, the quality of these data is largely unknown. Using poor quality data can result in lower program effectiveness, inefficient utilization of resources, lack of knowledge about existing system gaps, and poor program management.

Objectives: To measure accuracy of CHW data, defined as agreement between household registers compared to household member self-report and client records in one district in Eastern province, Rwanda.

Methods: We used cluster-lot quality assurance sampling (C-LQAS) to randomly sample six CHWs per cell (administrative unit of ~10 villages) and six households per CHW. We classified cells as having ‘poor’ or ‘good’ accuracy for household registers for five women and child health indicators. We calculated point estimates of percent of households with accurate data by health center. Data collection took place in households and at CHW homes between March and June 2012.

Results: We evaluated a total of 204 CHW household registers and 1224 households for data accuracy across 34 cells in southern Kayonza. There was considerable variability of data accuracy between indicators ranging from 23 of 34 cells classified as ‘good’ for *number of children under 5*, to 14 of 34 for *type of family planning method*. Point estimates of accurate household data across health centers for individual indicators ranged from 79% to 100%, while the composite indicator ranged from 61% to 72%. For four of the indicators, the data recording error seemed random. The indicator *number of women on modern family planning* was under-reported for 88% of households (95%CI: 86%, 90%) with median number under-reported of 1.

Conclusion: Data accuracy was largely ‘good’ across all cells, with some variation by indicator and challenges remain. Under-reporting of the indicator *women on modern family planning* may have been due to CHWs’ inability or unwillingness to collect this information. Program managers should identify optimum thresholds for ‘good’ data quality and interventions to reach them according to how data will be used. Decreasing variability of data and improving overall quality will facilitate the potential of these routinely-collected data for program improvement.

4.2 Introduction

A well-functioning health information system forms the backbone of an effective health system (WHO, 2007). Stakeholders at all levels use data from these systems to monitor, manage and evaluate programs and above all, to inform important decision-making processes. However, studies of facility-based health information systems carried out in sub-Saharan African countries have shown that data (both paper and electronic) can be of sub-optimal quality (Forster et al., 2008; Garrib et al., 2008; Makombe et al., 2008; Maokola et al., 2011; Mate et al., 2009; Mavimbe et al., 2005; Ndira et al., 2008; Rowe et al., 2009). In the last two decades, lay health workers have been deployed to increase access to important health services at the community level and achieve the Millennium Development Goals (MDGs) (Bhutta et al., 2010a; Bhutta et al., 2005; de Sousa et al., 2012; Hafeez et al., 2011; Haines et al., 2007; Lehmann et al., 2007; Prata et al., 2012; United Nations Statistics Division, 2012a; Young et al., 2012), and as a result are collecting and reporting on a large volume and range of information on a routine basis. While not as well documented, the quality of these data at the community level is also of variable quality.

A reliability study in Kisumu, Kenya found varying quality of community health worker (CHW) data depending on activity area; for example, latrine and antenatal care use were more reliable than immunization coverage indicators (Otieno et al., 2011). Authors found accuracy in monthly reports to be <50% in the national Lady Health Workers program in Pakistan, attributed to weak supervision and inappropriate and numerous data collection instruments (Mahmood et al., 2010). In another study in Ghana, misreporting was common, with health center staff shortages during community outreach being associated with under-reporting (Helleringer et al., 2010). In Neno, Malawi, Admon et al. (2013) found 25-44% of CHW reports pre-intervention to be unreliable depending on the indicator, due to inadequate time and skill for data aggregation (shifting aggregation responsibilities to specific, supervised CHW assistants immediately improved report quality).

While these data can provide information to guide health system priorities, identify gaps in service delivery and detect any emerging health issues, due to the concerns that exist around the quality of CHW data, it is important to question the appropriateness of using them to guide program management and evaluation.

The Rwanda national community health program was initiated in 1995 by the Ministry of Health (MoH) and now supports some 45,000 community health workers (CHWs) at the village level who are trained to deliver a broad range of preventive and curative services (MoH [Rwanda], 2008a; Mugeni, 2012). In each village (~100 households), there is one maternal health CHW who monitors pregnant women and their newborns, and at least two multi-disciplinary CHWs (*binômes*) who carry out: 1) integrated community case management (iCCM) (assessment, classification and treatment or referral of diarrhea, pneumonia, malaria and malnutrition in children under five years of age); 2) malnutrition screening; and 3) other preventive and behavior change activities (MoH [Rwanda], 2011b; Mugeni, 2011) (see Appendix 10.2 for full range of activities). CHWs are supervised from the cell (~10 villages), health center (~5 cells) and district (~10 health centers) levels. For each activity, there are corresponding standardized data collection tools and a monthly report comprising the community health information system (*Système d'Information de la Santé Communautaire* (SISCom))(MoH [Rwanda], 2008b).

As in many CHW programs, the MoH and its implementing partners use CHW-collected data for program management, evaluation and quality assurance of CHW activities. Additionally, some data are included in the national performance-based financing (PBF) system whereby the MoH makes quarterly payments into CHW cooperatives based on the quantity of certain activities reported and the timeliness and completeness of the reports. Given the reach of and resources already being poured into the CHW program in Rwanda, the MoH has expressed interest in being able to use CHWs as routine data collectors for household-level information (MoH [Rwanda] Community Health Desk, 2013).

There can be multiple quantifiable components of data quality (The Global Fund, 2008; WHO, 2008a); however, the objective of this study was to measure one component -- the accuracy -- of CHW data, defined as agreement between household register entries and household member self-report and direct observation of client-held cards in one district in Rwanda.

4.3 Methods

Study setting

The study was carried out in southern Kayonza district, Eastern province, Rwanda with a catchment area of approximately 150,000 persons. The international non-governmental organization Partners In Health (PIH) supports the full Ministry of Health (MoH) implementation of the CHW program in southern Kayonza district and provides additional enhancements in supervision, monitoring and evaluation (M&E), data use and trainings. CHWs in the PIH catchment area also provide a range of care beyond iCCM extending to the entire household, including monthly household visits and the use of a community health household register to collect key data, including information on basic demographic characteristics of all household members and target populations such as U5 children and women of reproductive age (Drobac et al., 2013).

The study focused on data collected by CHWs during their monthly household visits using the household register. The household register was developed and tested by PIH at the request of the MoH as a tool for CHWs to collect routine household-level data over time that could eventually be integrated into SISCom. The tool development process began in 2008 and district-wide implementation took place in October to November, 2011. One aim of this study was to provide evidence to support the PIH/MoH efforts to adapt and integrate the household register into SISCom.

The household register is designed to be used for the duration of one year by CHWs for all their households (~50) and includes 13 standardized lists to enable: 1) monitoring households and target populations; 2) standardized aggregation and reporting; and 3) CHW supervision at all levels. The lists include information on household members, children with possible malnutrition, women on family planning methods, pregnant women, suspected tuberculosis cases, deaths, household visits, meetings, trainings and supervision received. Data from the household registers fill current SISCom monthly village reporting gaps (at least 10 indicators).

Sampling and data collection

Lot Quality Assurance Sampling (LQAS) is an invaluable tool for decentralized health program monitoring and evaluation, both because of its simple sampling and analysis procedures and because the resulting classifications of an area link directly to an appropriate program response (Lwanga et al., 1991; Pagano et al., 2010; Robertson et al., 1997; Robertson et al., 2006; Valadez, 1991). In this study, we used the administrative unit, cells as 'lots' – the unit of classification – for the following reasons: first, we assumed that CHW data quality within a given cell would be relatively homogeneous due to the supervision structure (first level of supervision is at cell level), and between cells, it would potentially be variable; and second, because there is supervision at the cell level, classifications can be linked directly to follow-up actions by the cell-level supervisors.

In order to classify each cell as having 'good' or 'poor' quality household register entries, we used cluster-LQAS (C-LQAS), an adaptive form of LQAS intended to minimize resources by first sampling clusters and then randomly sampling individuals within clusters (Hedt-Gauthier et al., Under review; Olives et al., 2009; Pezzoli et al., 2010). To classify a cell, we randomly selected six CHWs per cell, and six households per CHW (36 total households) and compared household register tallies to self-report from household members, confirmed with direct observation of client-held cards (vaccination and family planning health records and national identification and insurance cards) if available during household visits (see Table 8). If five or more of the 36 household register entries were discordant with the household visit information (direct observation or self-report), the cell was classified as having ‘poor’ household register quality. Otherwise, the cell was classified as having ‘good’ household register quality.

The sample size and decision rule were selected to meet the following constraints based on discussions with PIH, Rwanda. PIH defined ‘good’ household register quality as 95% or more of household registers in a cell catchment area being concordant with the household visit information, with the risk of misclassifying such cells as ‘poor’ household register quality reduced to less than 10%. They defined ‘poor’ household register quality as a cell producing 75% or fewer household register entries concordant with the household visit information, with the risk of misclassifying such cells as ‘good’ household register quality reduced to less than 10%. Finally, because of increased misclassification error due to potential clustering in the data, we applied an estimated intraclass correlation of 0.15 from the existing literature and pilot data (Gilroy et al., 2004; Hedt-Gauthier et al., 2013; Rowe et al., 2002). These thresholds, allowable misclassification errors and intraclass correlation led to the recommended sample size (n=36 (m=6*k=6) per cell) and decision rule (d=5). More detail on the design and performance of C-LQAS can be found elsewhere (Hedt-Gauthier et al., 2013).

Data collection took place in January 2012 for the pilot test in one health center, and from May to June 2012 for the remaining health center catchment areas. The household registers were assessed for data quality through verification with household members and client-held health, insurance and identification cards. Household visits were conducted by a team of three trained Kinyarwanda-speaking data officers using a pre-tested tool including structured interview questions (see Appendix 10.10). Cell supervisors were notified of the CHWs sampled and a list of six households and six alternative households to sample with as little advance warning as possible to prevent possible data quality improvement between contact and observation. The supervisors passed on this information to the CHWs usually one or two days prior to the visit, and on the visit day, helped show the data officers where each CHW lived. The CHWs did not know the precise objective of the visit, but understood that it was for general supervision purposes. The CHWs were then asked to lead the data officers to the sampled households. If a household was not available (no female or male heads of household present), the CHW was asked to go down the alternative list until one was available. After introducing the data officer to the household members, the CHW moved out of visual and audio range.

For each key indicator listed below, the data officer assessed accuracy as recorded in the household register by asking household members structured questions (see Appendix 10.10). Whenever possible, the data officer re-confirmed oral responses by looking at written documentation in relevant client-held cards. After completion of the household visits, the data officer followed each CHW to his or her own home to extract data from the household register for the households visited. The household register remained with the data officer for the duration of the household visits to ensure it was not amended, but was returned once data had been extracted. Spot quality checks were carried out by the research supervisor who observed each data officer approximately once per week during data collection.

Variables and analysis

We evaluated the data quality of the household registers since inception (between October 2011 and January 2012 depending on CHW). We focused on a limited number of indicators based on MoH priorities: 1) the number of children U5 in the household; 2) the number of women 15-49 years of age in the household; 3) the number of women delivering at home since start of household register; 4) the number of women currently using a modern family planning method; and 5) the type of modern family planning methods used among all household members. We first evaluated the quality of each indicator separately – for a single indicator, we determined the household register entry to be discordant if the household visit information did not match exactly. We also looked at the household register data quality as a composite of the five indicators where a single household's register entries were determined to be discordant if the tallies did not match exactly on any one or more of the five indicators.

For each individual indicator and a composite of all indicators, we classified each cell as having 'good' or 'poor' data accuracy based on the decision rule (d=5). We calculated aggregate point estimates and 95% confidence intervals (95% CIs) for each health center and for the district, weighting the data to account for the varying number of households per cell. For discordant household entries, we have reported percentage over-reporting, median difference and interquartile range (IQR) by indicator and for the composite indicator.

Human subjects

Neither CHWs nor household members were compensated for their time. Cell supervisors were given pre-paid phone cards (approximately US$3) to assist with logistics of data collection. Village, cell and health center names and CHW unique ID were used in this study during data collection. Classifications were made at the cell level, de-identifying any individual CHW from the results. This study was approved by the Rwanda National Ethics Committee and the Brigham and Women's Hospital IRB under Partners Healthcare.

4.4 Results

A total of 34 cells, 204 CHWs and 1,224 households were included in this study across eight health center catchment areas in southern Kayonza district. Classifications of data accuracy in the household register were variable across individual indicators (see Table 10). The number of children U5 had the most cells classified as 'good' (23 of 34) followed by number of women on modern family planning method (19 of 34), number of women 15-49 years (18 of 34) and type of family planning method (14 of 34). However, no cell had concordant household register entries and visit information across all indicators (composite), though three (C24, C32, C34) had 'good' classifications for all individual indicators. Number of home deliveries in all but a few cases was a zero value and therefore made it difficult to assess accuracy (34 of 34 cells had 'good' classifications).

Point estimates of household register data accuracy at the health center level ranged from 79% to 100% for individual indicators, and 61% to 72% for the composite indicator (Table 12). As mentioned previously, number of home deliveries was the most accurate, whereas all other individual indicator point estimates were not statistically significantly different from each other. The number of women on modern family planning, when discordant, was consistently under-reported in the household registers as compared to household visit information by a median difference of -1 (IQR: -1, -1) (see Table 13). The median number of women on modern family planning per household was 0 (IQR: 0, 1) as recorded in the household registers (results not shown). However, there was no consistent pattern in over- or under-reporting for any of the other indicators.

4.5 Discussion

The utilization of CHWs as data collectors is not uncommon, particularly with the uptake of mobile device technology (Kalach, 2011; Millennium Villages Project, 2012; MobileActive.org, 2012; Tamrat et al., 2011; Tomlinson et al., 2009) as well as in humanitarian emergency (Bowden et al., 2012; Caleo et al., 2012) and research settings (Shah et al., 2010). CHWs have regular access to and often the trust of members in their community and can provide an efficient means of collecting and reporting on routine health-related data. Nevertheless, effective application of these data, as with information from any level of the health system, is contingent on confidence that the data are of sufficient quality to warrant their use. In the case of household register data, Rwanda may be close to achieving this, though there are still associated challenges.

The results of this study show that accuracy of household level CHW data was overall good for individual indicators, according to LQAS classifications by cell. This demonstrates that CHWs are able to collect raw information from household members on a routine and timely basis (and with a single data recording point). Further, given the lack of consistent patterns in over- or under-reporting (with the exception of *number of women on modern family planning method* indicator) the misreporting that did occur was for the most part random.

However, while accuracy of individual indicators was largely of 'good' quality, relatively low point estimates were observed for the composite indicator at the health center level. According to informal observations made during the study data collection process, this points to ongoing issues with data accuracy, including completeness of records (e.g. date of birth, sex or both missing for some household members) and timeliness (e.g. not updating household register with new or departed household members, pregnancy outcomes or change in family planning status since last visit).

Given the results of our study, and lingering potential challenges with data accuracy, we provide recommendations for improving overall CHW data quality, including practical considerations around the use of the LQAS-based methodology for routine assessments and implications for the Rwanda CHW program. We then describe limitations and generalizability of the study overall.

Practical considerations for routine accuracy assessments

The assessment of data accuracy in one district took a total of 34 days or seven weeks (one cell per day) to complete with three trained data officers including a substantial amount of logistical planning. Further, relative to some parts of the country, southern Kayonza has a fairly flat topography. Therefore, we do not suggest this evaluation be undertaken as a routine activity at health centers in Rwanda, or in countries where CHWs and households are geographically more spread out. Rather, it may be more practical to perform a baseline evaluation and subsequent annual or biannual assessments thereafter in order to monitor ongoing quality of CHW data, given their widespread use.

Recommendations for data accuracy improvement

As an alternative to formal routine data accuracy assessments, and to address the informal observations we made during the assessment, we suggest incorporating data quality checks into regular supervision visits and developing and implementing supervisor trainings specifically targeting improving data quality -- interventions which have worked in other settings at both the community and facility levels (Admon et al., 2013; Mphatswe et al., 2012). At the time of study, supervisors received the same training as CHWs (no additional training specific to supervision). Strengthening the supervision process can lead to improved data quality (Admon et al., 2013; Hedt-Gauthier et al., 2012; Helleringer et al., 2010; Makombe et al., 2008). To integrate on-the-spot data accuracy checks into routine supervision and training activities, we are developing a data quality checklist to provide specific guidance and a forum for feedback around areas needing improvement within the supervision structure. We also recommend conducting activities to encourage data use. If CHWs understand and are able to use the data they are collecting to facilitate their work, this can also improve data quality (Aqil et al., 2009; MEASURE Evaluation, 2012; Nutley, 2012).

Implications for Rwanda CHW program

In order for program managers to use CHW data, it is important to consider the margin of error that would be acceptable for each specific purpose. In Kenya, CHW data with 90% agreement were assessed to be adequate for local program planning and action, but not to guide higher level policy (Otieno et al., 2011). In this study, while number of women 15-49 years was over-reported by two percent (1436 versus 1410) among the sample taken at the district level, number of women on family planning method was under-reported by 27% (339 versus 429). These totals represent 1,224 households of approximately 30,000 in the total study catchment area, and a mere fraction of the total country. When taking into account larger populations, these differences might be amplified.

The thresholds for ‘good’ and ‘poor’ household register quality were based on discussions with PIH. However, the most meaningful thresholds for the national program may differ depending on the intended use of the data. As the MoH moves to integrate the household register into the broader SISCom, it will be considering how and when household level data will be collected by CHWs and subsequently how they will be used and with what confidence.

Limitations

One limitation of the study was the reliance on self-report to verify potentially sensitive information such as family planning methods used or place of delivery. For example, due to social norms around fertility in Rwanda, it is assumed that single, childless women do not use birth control. However, this is corroborated in the 2010 Rwanda Demographic and Health Survey data which showed 99% of childless women not currently using any method of contraception versus 41-47% of women with at least one child (National Institute of Statistics of Rwanda (NISR) et al., 2012). Additionally, the Government of Rwanda (GoR) strongly encourages women to deliver at a health facility; the MoH offers supply-side incentives to maternal health CHWs through the PBF system to accompany women for facility deliveries, and provides a random sample of pregnant women across the country with non-monetary demand-side incentives to deliver at a facility as part of an impact evaluation study on community PBF (Basinga, 2011; De Naeyer, 2011; MoH [Rwanda], 2009; MoH [Rwanda] Community Health Desk, 2013). During an interview, this might incline the household member not to admit having a home birth. External evaluators such as data officers may not be trusted to provide such potentially sensitive information; however, it appears that when there was discordance between the household register and information gathered from the household visits, it was the household register that under-reported indicators. Therefore, the household members seemed more likely to be forthcoming with sensitive information to external evaluators than to CHWs who live in their community. Furthermore, self-reported family planning information was almost always confirmed with the client-held family planning card.

Anecdotally, we found that when data officers were able to interview the female head of the household, information was forthcoming and she was knowledgeable. The male heads of household were less informed about their children's age and wife's family planning status. However, in all but a few cases (not documented), the interviewee was the female head of household.

If CHWs were notified too early and understood that they were going to be evaluated on the data quality of the household register, they may have been able to complete or correct household register entries accordingly. We tried to reduce this outcome by alerting CHWs as late as possible regarding the assessment activity, and describing it as a routine supervision visit. In general, CHWs were notified from one to seven days in advance.

This study looked at only one component of data quality of the household registers – accuracy; however, in this study accuracy not only implies reliability, but also includes measures of completeness and timeliness. CHWs are supposed to update the household register during their monthly household visits; therefore, discordance between household register and visit tallies would have been present if a child was born in the last month or a child U5 or woman of reproductive age had died in the same period but not recorded as such. Likewise, any missing data (incompleteness) would have also resulted in discordance (for any non-zero value); for example, a woman using a modern family planning method if not recorded, would not have matched the household visit tally.

Generalizability

The CHW program in PIH-supported districts including southern Kayonza is enhanced through additional monthly compensation for CHWs, stricter criteria (higher education, dedicated position) for cell-level CHW supervisors, an additional health center-level clinically-trained CHW supervisor, and a smaller geographic catchment area per CHW with monthly household visits, amongst others. While these factors may have contributed to the level of data quality measured in this study, in a presentation comparing data reliability across three districts, we found that southern Kayonza experienced similar challenges as two neighboring districts without PIH support (Mitsunaga T & Hedt-Gauthier B et al., 2012a). Further, the MoH is currently working with PIH to see how the household register can be modified to fit within existing national structures (without PIH support). This may include reduced number of household visits (from monthly to quarterly) or using maternal health CHWs to reduce per CHW geographic coverage, for example. Additionally, the MoH currently uses population number estimates (for children U5, women of reproductive age and total population) as denominators for some SISCom indicators (e.g. contraceptive prevalence) (Basinga, 2011). If of adequate quality, these numbers could come directly from the household register even if collected/updated on an annual basis and provide more accurate estimates.

Conclusion

This study demonstrated that CHWs are generally capable of collecting accurate household-level data, though through informal observations we noted issues in timeliness and completeness of data in some cases. Nevertheless, there is potential to be able to use these data for actual population number denominators or other useful information collected and reported on a routine basis. To this end, the Rwandan government must decide how accurate these data must be (thresholds) in order to employ them for these different purposes.

4.6 *Tables for Chapter 4*

Table 10. Classification of data accuracy comparing household registers to self-report by indicator and cell in southern Kayonza

Cell	# children under-5		# women 15-49		# women on modern FP		Type of family planning		# home deliveries		Composite	
	# not match	Classif-ication	# not match	Classif-ication	# not matching	Classif-ication	# not match	Classif-ication	# not match	Classif-ication	# not match	Classif-ication
C1	4	Good	11	Poor	4	Good	5	Poor	0	Good	16	Poor
C2	3	Good	7	Poor	7	Poor	7	Poor	0	Good	14	Poor
C3	4	Good	8	Poor	7	Poor	9	Poor	0	Good	18	Poor
C4	0	Good	2	Good	3	Good	6	Poor	0	Good	8	Poor
C5	4	Good	6	Poor	2	Good	4	Good	0	Good	12	Poor
C6	1	Good	4	Poor	5	Poor	5	Poor	0	Good	9	Poor
C7	3	Good	2	Good	5	Poor	5	Poor	1	Good	9	Poor
C8	5	Poor	7	Poor	5	Poor	7	Poor	1	Good	16	Poor
C9	3	Good	5	Poor	3	Good	2	Good	0	Good	9	Poor
C10	3	Good	0	Good	1	Good	5	Poor	0	Good	8	Poor
C11	4	Good	1	Good	7	Poor	6	Poor	0	Good	11	Poor
C12	4	Good	4	Good	5	Poor	6	Poor	0	Good	12	Poor
C13	4	Good	4	Good	2	Good	6	Poor	1	Good	12	Poor
C14	8	Poor	6	Poor	2	Good	3	Good	0	Good	14	Poor
C15	2	Good	5	Poor	3	Good	4	Good	0	Good	10	Poor
C16	2	Good	6	Poor	7	Poor	10	Poor	1	Good	16	Poor
C17	5	Poor	4	Good	4	Good	3	Good	0	Good	12	Poor
C18	7	Poor	4	Good	5	Poor	4	Good	1	Good	17	Poor
C19	4	Good	4	Good	7	Poor	6	Poor	0	Good	11	Poor
C20*	4	Good	5	Poor	4	Good	5	Poor	0	Good	12	Poor
C21	6	Poor	8	Poor	3	Good	3	Good	0	Good	14	Poor
C22	9	Poor	5	Poor	5	Poor	5	Poor	1	Good	14	Poor
C23	2	Good	0	Good	6	Poor	5	Poor	0	Good	6	Poor
C24	3	Good	2	Good	4	Good	4	Good	0	Good	9	Poor
C25	4	Good	4	Good	4	Good	6	Poor	0	Good	11	Poor
C26*	6	Poor	7	Poor	3	Good	3	Good	0	Good	14	Poor
C27	6	Poor	3	Good	4	Good	4	Good	0	Good	12	Poor
C28	2	Good	5	Poor	3	Good	7	Poor	0	Good	13	Poor
C29	6	Poor	7	Poor	5	Poor	5	Poor	1	Good	15	Poor
C30	7	Poor	3	Good	6	Poor	4	Good	0	Good	11	Poor
C31	4	Good	2	Good	3	Good	5	Poor	0	Good	7	Poor
C32	4	Good	4	Good	1	Good	1	Good	0	Good	8	Poor
C33	5	Poor	3	Good	5	Poor	4	Good	0	Good	11	Poor
C34	4	Good	2	Good	2	Good	3	Good	0	Good	8	Poor

*Cells have 35 instead of 36 households with complete data for Type of family planning indicator

Table 11. Classification of data accuracy comparing household registers to self-report by indicator and health center catchment area in southern Kayonza

	Health Center Catchment Area							
	SKHC1	**SKHC2**	**SKHC3**	**SKHC4**	**SKHC5**	**SKHC6**	**SKHC7**	**SKHC8**
# cells	5	4	5	4	4	4	1	7
Indicator	**Number of cells with 'good' data accuracy**							
# children under 5	5	3	4	2	2	3	0	4
# women 15-49	1	1	4	2	1	3	1	5
# women on modern family planning	3	1	3	2	2	3	1	4
Type of family planning	1	1	1	3	1	2	1	4
# home deliveries	5	4	5	4	4	4	1	7
Composite	0	0	0	0	0	0	0	0

Table 12. Point estimate and 95% confidence intervals of data accuracy comparing household registers to self-report by indicator and health center catchment area / district

Health Center / District	**Indicator**					
	# children under-5	# women 15-49	# women on modern family planning	Type of family planning	# home deliveries	Composite
	Point estimate (95%CI)					
SKHC1	91.3% (86.9%, 95.8%)	79.5% (73.2%, 85.8%)	88.0% (83.0%, 92.9%)	83.8% (78.2%, 89.4%)	100.0% (NA)	61.5% (54.1%, 68.9%)
SKHC2	91.3% (86.3%, 96.2%)	87.4% (81.8%, 93.1%)	86.8% (80.9%, 92.7%)	85.3% (79.1%, 91.5%)	98.3% (95.9%, 101%)	68.6% (60.8%, 76.5%)
SKHC3	86.6% (81.5%, 91.8%)	91.6% (87.5%, 95.7%)	91.9% (88.2%, 95.6%)	86.3% (81.2%, 91.3%)	99.5% (98.5%, 100%)	68.5% (61.6%, 75.4%)
SKHC4	88.5% (83.2%, 93.7%)	86.9% (81.4%, 92.4%)	86.5% (80.9%, 92.1%)	85.3% (79.6%, 90.9%)	98.5% (96.5%, 101%)	61.1% (53.2%, 69.1%)
SKHC5	84.5% (78.6%, 90.4%)	84.4% (78.4%, 90.4%)	87.0% (81.6%, 92.5%)	86.9% (81.4%, 92.4%)	99.4% (98.4%, 101%)	64.7% (56.8%, 72.5%)
SKHC6	89.4% (84.3%, 94.4%)	90.6% (85.8%, 95.3%)	88.5% (83.4%, 93.7%)	87.7% (82.3%, 93.0%)	100.0% (NA)	71.7% (64.3%, 79.0%)
SKHC7	83.3% (71.2%, 95.5%)	91.7% (82.6%, 101%)	88.9% (78.6%, 99.1%)	88.9% (78.6%, 99.1%)	100.0% (NA)	66.7% (51.3%, 82.0%)
SKHC8	87.3% (83.3%, 91.4%)	90.0% (86.4%, 93.6%)	89.5% (85.8%, 93.3%)	87.4% (83.3%, 91.5%)	99.7% (99.2%, 100%)	70.4% (64.9%, 76.0%)
District	88.3% (86.4%, 90.2%)	86.8% (84.7%, 88.8%)	88.2% (86.3%, 90.2%)	86.1% (84.0%, 88.2%)	99.4% (98.9%, 99.9%)	66.5% (63.7%, 69.3%)

Table 13. Of discordant household register entries, % over-reporting in household register compared with household visit information, median difference and interquartile range (IQR) by health center catchment area and district by indicator

Health Center / District	**Indicator**					
	Number of children under five years		Number of women 15-49 years		Number of women on modern family planning method	
	% HH register > HH visit | Median difference (IQR)					
SKHC1	12.3%	-1(-1,-1)	66.7%	1(-1,1)	20.8%	-1(-1,-1)
SKHC2	48.5%	0(-1,1)	50.2%	-1(-1,1)	8.8%	-1(-1,-1)
SKHC3	30.7%	-1(-1,1)	76.5%	1(-1,1)	16.4%	-1(-1,-1)
SKHC4	25.7%	-1(-1,0)	67.2%	1(-1,1)	22.5%	-1(-1,-1)
SKHC5	38.5%	-1(-2,1)	53.7%	1(-1,1)	19.6%	-1(-1,-1)
SKHC6	27.1%	-1(-1,1)	60.0%	1(-1,1)	12.1%	-1(-1,-1)
SKHC7	33.3%	-1(-2,1)	33.3%	-1(-1,1)	25.0%	-1(-1, 0)
SKHC8	44.1%	-1(-1,1)	35.3%	-1(-1,1)	35.9%	-1(-1,1)
District	33.7%	-1(-1,1)	57.4%	1(-1,1)	19.7%	-1(-1,-1)

Chapter 5. “Measuring reliability of data in monthly village-level community health reports, Eastern Province Rwanda” (Manuscript 2)

5.1 Abstract

Background: In order to reach the Millennium Development Goals, countries like Rwanda deliver many health services through community health workers (CHWs). Consequently, CHWs routinely collect and report on considerable amounts of information, which is employed at all levels of the health system for decision-making. However, the quality of these data is largely unknown, and poor quality data can result in lower program effectiveness, inefficient utilization of resources, lack of knowledge about existing system gaps, and poor program management.

Objective: To measure reliability of CHW data, defined as agreement between monthly village-level community health information system reports, compared to CHW forms and registers in three districts with varying partner support in Eastern province, Rwanda.

Methods: Through Lot Quality Assurance Sampling (LQAS) we randomly sampled 19 or 25 villages per health center catchment area (depending on size) and then classified these catchment areas as having ‘poor’ or ‘good’ reliability for village reports for three community case management indicators and calculate point estimates by district. The study was conducted at the health centers with CHWs bringing tools for assessment from May 2011 to March 2012.

Results: Overall, 501 village reports were assessed to classify data reliability from 27 health center catchment areas. In southern and northern Kayonza districts, one out of eight and six health center catchment areas respectively had ‘good’ data quality for two indicators (*total sick children* seen and *children treated for pneumonia and recovered*). In Kirehe, nine and 13 of 13 health center catchment areas had ‘good’ classifications for the same indicators, respectively. The third indicator (*children treated for fever and referred to health center*) when misreported was over-reported by a median of 2 (IQR: 1,3) in northern Kayonza and Kirehe and 3 (IQR: 1,4) in southern Kayonza. Otherwise, reporting error was largely random. Point estimates for the composite indicator (‘good’ only if all three indicators were concordant) were 26% (95%CI: 21%, 32%) for southern Kayonza; 32% (95%CI: 26%, 38%) in northern Kayonza; and 60% (95CI: 55%, 65%) in Kirehe.

Conclusion: This study demonstrated gaps in data reliability within the iCCM program in Rwanda. However, we also suggest potential reasons and ways in which to address these issues to improve overall CHW data quality. Further, we believe the act of conducting ongoing assessments can improve data reliability and use and can identify areas needing additional support. The lessons learned, recommendations and data quality assessment methodology extend to other CHW programs in Rwanda, and more globally and utility of these data for health program management, evaluation and quality assurance. Finally, more rigorous evaluations of factors related to CHW data quality may confirm or complement our anecdotal observations, leading to more pointed policy implications for all CHW programs.

5.2 Introduction

Community health workers (CHWs) have been used to deliver important health services at the household and community levels for decades, including to help achieve "health for all" (Berman et al., 1987; WHO, 1978) and more recently to reduce child and maternal mortality as set forth by Millennium Development Goals 4 and 5 (Bhutta et al., 2010a; Bhutta et al., 2005; Bhutta et al., 2010b; de Sousa et al., 2012; Edward et al., 2007; Hafeez et al., 2011; Haines et al., 2007; Lehmann et al., 2007; Prata et al., 2012; United Nations Statistics Division, 2012a; WHO/UNICEF, 2004a, 2004b; Young et al., 2012). The objectives of such programs include increasing access to care by removing barriers of distance and costs, identifying and treating illness earlier, and monitoring uptake of health programs.

In addition to improving access to health care, CHWs are collecting and reporting on a large volume and range of information on a routine basis. Currently, these data are employed at all levels to monitor, manage and evaluate CHW programs. Further, the data provide information to guide health system priorities, identify gaps in service delivery, and detect any emerging health issues. Indeed, a well-functioning health information system, including the data collected during community-level service delivery, forms the backbone of an effective health system (WHO, 2007).

However, concerns exist around the quality of CHW data and as a result, the appropriateness of using them to guide program management and evaluation. Studies of facility-based health information systems carried out in sub-Saharan African countries have shown that data (both paper and electronic) can be of sub-optimal quality (Forster et al., 2008; Garrib et al., 2008; Makombe et al., 2008; Maokola et al., 2011; Mate et al., 2009; Mavimbe et al., 2005; Ndira et al., 2008; Rowe et al., 2009). To date, very few studies have assessed the quality of and factors affecting data collected and reported by CHWs. A reliability study in Kisumu, Kenya found varying quality of CHW data depending on activity area; for example, latrine and antenatal care use were more reliable than immunization coverage indicators (Otieno et al., 2011). Authors found accuracy in monthly reports to be <50% in the national Lady Health Workers program in Pakistan, attributed to weak supervision and inappropriate and numerous data collection instruments (Mahmood et al., 2010). In another study in Ghana, misreporting was common, with health center staff shortages during community outreach being associated with under-reporting (Helleringer et al., 2010). While tools exist to assess the quality of facility-based data (Aqil et al., 2009; The Global Fund, 2008), there is no such standardized, routine methodology for measuring CHW data quality either on its own or as part of a broader community-based health information system.

The Rwanda national community health program was initiated in 1995 by the Ministry of Health (MoH) and now supports some 45,000 CHWs at the village level (MoH [Rwanda], 2008a; Mugeni, 2012). In 2005, the MoH designed a revised comprehensive CHW system to deliver a broader range of preventive and curative services, and is currently training two types of CHWs to carry out these activities. In each village (roughly 50-150 households), there is a maternal health CHW who monitors pregnant women and their newborns, and at least two multi-disciplinary CHWs (*binômes*) who carry out: 1) integrated community case management (iCCM) (a global strategy adapted by Rwanda including the assessment, classification and treatment or referral of diarrhea, pneumonia, malaria and malnutrition in children under five years of age (U5) (MoH [Rwanda], 2011b; Young et al., 2012)); 2) malnutrition screening; and 3) other preventive and behavior change activities (MoH [Rwanda], 2011b; Mugeni, 2011). For each activity, there are corresponding standardized data collection tools and a monthly report comprising the community health information system (*Système d'Information de la Santé Communautaire* (SISCom))(MoH [Rwanda], 2008b).

The MoH and its partners use data from the SISCom monthly reports for program management, evaluation and quality assurance of CHW activities. Additionally, these report data are included in the national performance-based financing (PBF) system whereby the MoH makes quarterly payments into CHW cooperatives based on the quantity of certain (non-treatment-related) activities reported and the timeliness and completeness of the reports (see Appendix 10.3) (MoH [Rwanda], 2009). In a different assessment comparing CHW household (not iCCM) register data and household interviews or client-held cards in one district in Rwanda, we found CHWs were largely capable of collecting accurate household-level data (Mitsunaga T & Hedt-Gauthier B et al., 2012b). However, these data, along with information from the iCCM program are then aggregated into reports (see Methods section). This underscores the importance of validating the ability of CHWs to accurately aggregate data.

While there can be multiple quantifiable components of data quality (The Global Fund, 2008; WHO, 2008a), the objective of this study was to measure the reliability of CHW data (or the accuracy of data aggregation), defined as agreement between monthly village-level SISCom reports, compared to CHW iCCM registers in three districts with varying partner support in Rwanda.

5.3 Methods

Study setting

The study was carried out in southern and northern Kayonza and Kirehe districts, Eastern province, Rwanda. The total catchment area is roughly 540,000 persons. The international non-governmental organization Partners In Health (PIH) supports the full Ministry of Health (MoH) implementation of the CHW program in southern Kayonza district in addition to enhancements in supervision, monitoring and evaluation (M&E), data use and trainings (see Appendix 10.4). CHWs in the PIH catchment area also provide a range of care extending to the entire household, beyond iCCM including monthly household visits (Drobac et al., 2013). Another partner, IRC (International Rescue Committee) provides technical and financial support to the iCCM program in Kirehe. This includes support around M&E, training and quality improvement of iCCM activities. EGPAF (Elizabeth Glaser Pediatric AIDS Foundation) supports HIV-related activities in northern Kayonza.

For this study, we focused on data collected and reported by *binômes* (hereafter "CHWs") for their iCCM activities. During each sick child visit, CHWs complete a sick child encounter form (hereafter "form")(Appendix 10.5). They transfer key elements from each form into an iCCM consultation register (hereafter "register")(Appendix 10.6) – one line per sick child – and tally the register data to generate the monthly village-level SISCom report (hereafter "report")(Appendix 10.7). The report is a combined aggregation of activities carried out by all CHWs (and maternal health CHWs) in one village. The village reports are then aggregated at the cell (comprising ~10 villages) level, and then sector (generally corresponding to the health center) level. These reports are sent to the district level where the data are entered and transmitted electronically to the central level for analysis and feedback (Figure 3). At each health center, CHWs receive a four-day iCCM training including how to fill out the forms and registers with annual refresher trainings thereafter), and a one-day training on how to fill out the report. Health center-level community health supervisors are responsible for all CHW trainings and monthly meetings.

Sampling

Lot Quality Assurance Sampling (LQAS) is an invaluable tool for decentralized health program monitoring and evaluation, both because of its simple sampling and analysis procedures and the resulting classifications of an area link directly to an appropriate program response (Lwanga et al., 1991; Pagano et al., 2010; Robertson et al., 1997; Robertson et al., 2006; Valadez, 1991). LQAS was originally developed and employed to control quality of industrially produced goods in the 1920s; a relatively small sample size is needed to determine whether a 'lot' has reached an acceptable level of quality, coverage, supervision, or other outcome. Upper and lower thresholds must be identified as acceptable and unacceptable cutoffs for the outcome (Robertson et al., 2006).

We selected health centers and the CHWs deployed in their catchment areas as our 'lots' assuming that CHWs are trained and supervised uniformly within a health center, but not necessarily so across health centers. We applied LQAS decision criteria to classify each of the health center catchment areas as having 'good' or 'poor' quality reports, with the aim of strengthening those classified as having 'poor' report quality. To classify a health center catchment area, we randomly selected 19 villages for health centers with <65 villages; and 25 for those with ≥65 villages in the catchment area. We made two comparisons: 1) report totals compared to register tallies; and 2) report totals compared to form tallies (in southern Kayonza district only). For both comparisons, if ≥4 of the 19 reports or ≥5 of the 25 reports were discordant with the register or form tallies in that village, the health center catchment area was classified as having 'poor' report quality. Otherwise, it was classified as having 'good' report quality. For health center catchment areas with ≤25 villages, we took a census.

Upper and lower thresholds were identified through discussions with PIH, Rwanda: they defined 'good' report quality as ≥90% of reports in a health center catchment area being concordant with the register, with the risk of misclassifying such health center catchment areas as ‘poor’ report quality reduced to <10%; and ‘poor’ report quality as a health center catchment area producing <70% of reports concordant with the registers, with the risk of misclassifying such health center catchment areas as ‘good’ report quality reduced to <10%. The choices of these thresholds and allowable misclassification errors resulted in the recommended sample size (n=19 per health center catchment area) and decision rule (d=4) based on the limited number of villages in most health center catchment areas (for those with <65 villages) (Appendix 10.9). In the three health center catchment areas in Kirehe district containing 65 or more villages, the recommended sample size (n) was 25 per health center with a decision rule (d=5). For health center catchment areas across all districts with 25 or fewer villages, we took a census (see Table 6 for sample sizes).

Data collection

Data collection took place from May to June 2011 in southern Kayonza; October to November, 2011 in Kirehe; and March to April 2012 in northern Kayonza. At each health center, two to three trained data officers tallied indicators from each CHW’s register (and forms in southern Kayonza only), and extracted totals from each village report using pre-tested algorithms and data collection forms (Appendix 10.11). Data collection took one to two days depending on the number of attending CHWs. Sampled CHWs who did not visit the facility on their assigned days were actively traced. CHWs were compensated for coming to their health centers with their forms, registers and reports.

In four of the eight health center catchment areas in southern Kayonza, we sampled 19 reports to apply LQAS classifications. In the remaining four, we took a census of reports from all villages to evaluate the accuracy of the LQAS classification. We focused on a randomly chosen subset of 19 from all health center catchment areas across the three districts for which we took a census in our results but also presented the results of the census in southern Kayonza only.

Additionally, data collectors and investigators carried out informal observations and interviews with CHWs and supervisors during data collection in order to better understand the process of how data were collected and the root of the errors seen. While anecdotal, this information is presented in the Discussion section.

Analysis

We evaluated the data quality of the April 2011 report across all districts for consistency. The report collects over 50 data elements. For this study, we focused on a limited number of indicators as defined by SISCom: 1) the number of sick children under five years seen in the last month (total sick children indicator); 2) the number of children 6-59 months who were treated for fever [with anti-malarials] within 24 hours and were referred to the health center (fever indicator); and 3) the number of children [2-59 months] treated for pneumonia [with amoxicillin] who recovered (pneumonia indicator). We first evaluated the quality of each indicator separately – for a single indicator, we determined the report to be discordant if the tallies of the register data and number in the report did not match exactly. We also looked at the report quality as a composite of the three indicators where a single report was determined to be discordant if the tallies did not match exactly on any one or more of the three indicators. We made the same comparisons on individual indicators and the composite indicator between the report and the forms (for southern Kayonza only).

We classified health center catchment areas as having ‘good’ or ‘poor’ quality data. We calculated district-level point estimates with 95% confidence intervals (95%CIs) for each indicator and composite indicator by district, weighting the sample by number of villages in each health center catchment area.

Human subjects

No identifying information on iCCM clients was recorded. This study was approved by the Rwanda National Ethics Committee and the Brigham and Women’s Hospital IRB under Partners Healthcare.

5.4 Results

We reviewed the reports, registers and forms from 175 out of 251 total villages in southern Kayonza. Of the 175 reports, only one was missing (from health center SKHC8), and 140 were included in the LQAS analysis. In northern Kayonza, we analyzed the full sample of 100 reports and registers out of 171 total villages. In Kirehe while we looked at 263 reports and registers, we analyzed 261 reports (sampled 19 from one health center catchment area with 21 villages) from 614 total villages. We looked at data from April 2011 reports; however, due to tight reporting deadlines at the higher administrative levels, the actual reporting dates ranged from March 23 to April 28 2011.

Southern Kayonza

The number of reports discordant with the registers and the corresponding LQAS classifications for southern Kayonza are presented in Table 14. With few exceptions, health center catchment areas were classified as having 'poor' report quality for all three indicators. All health center catchment areas were classified as having 'poor' report quality when analyzing the composite indicator. We observed similar results when comparing the numbers reported in the report to the numbers documented in the forms. Therefore, all subsequent comparisons (for northern Kayonza and Kirehe districts) were carried out with registers only. For health centers SKHC2-4, we found the LQAS classifications to be accurate as compared to the results from the census.

We estimated the percentage of reports of 'good' quality across all health center catchment areas in the district. For the total sick children, fever and pneumonia indicators respectively, 59% (95% confidence interval (CI): 53%, 65%); 58% (95%CI: 52%, 63%); and 71% (95%CI: 66%, 76%) of reports agreed with registers and 53% (95%CI: 47%, 59%); 57% (95%CI: 51%, 62%); and 79% (95%CI: 74%, 83%) agreed with the forms. For the total sick children and pneumonia indicators, discordant reports did not favor over- or under-reporting, whereas almost all reports over-reported the fever indicator (98% (95%CI: 94%, 100%) by a median difference of three (IQR: 1,4). The mean number of total sick children seen as tallied in the registers was 2.2 across all three districts (95%CI: 1.7, 2.6)(Table 24).

For the composite indicator, concordance was 26% (95%CI: 21%, 32%) between reports and registers and 27% (95%CI: 22%, 33%) between reports and forms.

Northern Kayonza

Similarly, reports in northern Kayonza were largely of ‘poor’ quality across all indicators with the exception of the fever indicator, where half of health center catchment areas had reports of ‘good’ quality (see Table 15). However, there were many zero values in both reports and registers (see discussion below). As with southern Kayonza, all health center catchment areas were classified as having ‘poor’ data quality for the composite indicator.

Aggregate point estimates of data quality were higher than for southern Kayonza with the fever indicator performing the best at 76% (95%CI: 70%, 81%) followed by the pneumonia indicator at 72% (95%CI: 66%, 78%) and total sick children seen at 64% (95%CI: 59%, 70%). The composite indicator remained very low at 32% (95%CI: 26%, 38%). Both the fever and pneumonia indicators were over-reported when discordant by a median difference of two (IQR: 1, 3) and one (IQR: 1, 2) respectively.

Kirehe

Kirehe district had many more (both absolute and relative in number) health center catchment areas classified with ‘good’ data quality across all indicators. All health center catchment areas were classified with ‘good’ data quality for the pneumonia indicator, as well as nine, four and two out of thirteen health center catchment areas for the total sick children seen, fever and composite indicators respectively.

Likewise, point estimates for the district were significantly higher than for the other two districts across all indicators except for the fever one (see Table 18). Yet, the composite indicator was still low at 60% (95%CI: 55%, 65%). Like the other two districts, the fever indicator, when discordant, was over-reported by a median difference of two (IQR: 1, 3).

5.5 Discussion

CHW-generated data are utilized extensively by governments and their partner organizations for program management, evaluation and quality assurance; therefore, it is critical that these stakeholders are confident that the data are of sufficient quality to warrant their use. In the previous chapter, we showed that CHWs are largely able to collect accurate household level data; however, the data that are used in Rwanda and many other settings are often aggregated in report format. Our results show that data quality of CHW monthly village reports in Rwanda, measured as reliability in this study, was overall ‘poor’ across health center catchment areas in three districts. This reveals that CHWs indeed have trouble aggregating data correctly. We discuss potential reasons for this based on informal observations and interviews with CHWs and supervisors during the data collection process. Then, given that the reports, and not the source data are used for decision-making, we follow up with actions already taken and recommendations on ways to improve the quality of CHW data reliability, including considerations for applying the LQAS-based methodology to future routine data quality assessments. Finally, we describe strengths, limitations and generalizability of the study.

Potential factors related to data reliability

Despite a well-structured and –supported national CHW program including the development and use of a standardized community health information system (SISCom) in Rwanda, there are clearly still challenges to achieving high quality CHW reports. While Chapter 6 presents results of a more formal evaluation of factors associated with CHW data quality, anecdotal observations and informal interviews with the CHWs and supervisors made during the study provide complementary insight into these challenges.

Data reliability differed across the three districts, with Kirehe district clearly out-performing the other two. This might be due in part to the earlier initiation of iCCM in Kirehe as a pilot district (2006 versus 2009) leading to more CHW experience completing the forms, as well as focused partner support for iCCM-related M&E.

Nevertheless, all health centers fell below the threshold for 'good' data quality for the composite indicator classification. Health centers fared best with the pneumonia indicator; however this is likely attributable to the fact that often no children with pneumonia were treated by CHWs. For all indicators, the reporting of zero-events was consistent and usually correct across all source records (reports, registers and forms) (results not shown).

Misreporting of the selected indicators in this study appears to not have been purposeful or ill-motivated: the consistent over-reporting of the fever indicator may rather be attributed to misinterpretation of the definition of 'treatment' [with anti-malarials] with rapid diagnostic testing (RDT), a function of mismatched updated algorithms with older versions of forms.

For the pneumonia and total sick children seen indicators, when discrepancies existed, there was no consistency of over- or under-reporting as indicated by the IQR with the exception of over-reporting of the pneumonia indicator in northern Kayonza. This randomness in errors points to a variety of sources beyond a lack of understanding of the indicator, such as incomplete documentation in encounter forms and registers, failure to fill in encounter forms and registers, and errors in aggregation which we expand on below. While not ideal, the randomness of errors in reporting may allay potential fear that CHWs may be over-reporting certain indicators for which they receive compensation through the PBF system (though over-treating may still be an issue).

Several factors observed informally during data collection seemed to affect data quality. These were not systematically measured and therefore do not appear in the following chapter; however, these systems- and CHW-related factors may provide a broader perspective of the national CHW program in Rwanda. At the time of study, potential systems factors included:

1) **Availability of forms**. In some health centers, CHWs had run out of sick child forms. Therefore, they were either not treating children or they were filling in the registers in lieu of the form. As a result, there would always be a discrepancy between the number of children seen on the forms and the report or register. This issue seems widespread as Basinga (2011) reported more than half of all CHWs interviewed at baseline in an evaluation of Rwanda's community PBF were lacking a complete stock of health registers/books, among other supplies.
2) **Clarity of definitions of indicators in report**. Some data elements requested for the monthly report were not well-defined or combined multiple elements. This may have led to confusion about the values to report among CHWs and their supervisors. As a result, there was non-uniformity in data collection and aggregation across health centers and CHWs.
3) **Compatibility of recording and reporting tools.** Components of the report did not always directly align with data elements captured by the register. This was also the case between the form and the register. Poor alignment of some elements captured in the forms and registers and reported in the monthly report would have contributed to poor data quality.
4) **Variability and quality of health center-level training and supervision**. The quality of iCCM or monthly report training and their supervision at each health centers may have been inconsistent, as has been observed informally during other CHW program trainings. Certainly, we noted differences in understanding of how to complete the tools by health center supervisors, which resulted in variation in recording, reporting and data quality. For example, notation of 'yes' and 'no' in

registers, misreporting of the fever indicator, and using the register only for paying clients. Secondly, monthly report training was not practicum-based; rather, it consisted of verbal instruction on what the indicators were and how to fill out the report. This absence of hands-on practice (real-time aggregation from registers to reports) may have resulted in sub-optimal comprehension by CHWs of how to tally the reports.

CHW data quality studies carried out in other settings support these observations of inadequate or inappropriate supervision, training and tools for data aggregation (see Chapter 6) (Admon et al., 2013; Helleringer et al., 2010; Mahmood et al., 2010). These issues for the most part are what Aqil et al. (2009) term 'technical factors' in their framework for routine information systems – those related to the design and technology of the overall health information system. Using the same framework, the second set of issues fall mainly into the category of 'organizational' or 'behavioral' factors (see Chapter 6). These were CHW-related factors and included:

1) **Literacy and numeracy**. Some CHWs lacked the required primary school education, limiting their ability to understand, record or tally information correctly. While selection criteria for CHWs included primary education and basic literacy, this was not always strictly enforced.
2) **Comprehension of training**. If CHWs did not understand the tools or how to use them, or used them incorrectly, they would have produced data of poor quality.
3) **Experience using iCCM tools**. The sick child encounter form and consultation register represent only two of the five tools used within the iCCM program. Given

the number and potential complexity introduced by having numerous tools, a more experienced CHW may have better mastery in their use over a less experienced one (this may have been the case with the more experienced Kirehe CHWs).

4) **Patient volume**. Similarly, the more sick children seen, the more the tools were used (leading to mastery). In 2010, the MoH carried out a rapid assessment of quality of care by CHWs implementing iCCM in which the more experience CHWs had spent carrying out iCCM and the fewer the number of presenting symptoms a child had were associated with better CHW adherence to treatment protocols (MoH [Rwanda], 2011a). This may also hold true for data quality. CHWs having more experience treating patients whether through high patient volume or number of years as CHW may contribute to more comfort with recording and reporting data and therefore improved data quality; however, the opposite could prove true – the more sick children tallied from the registers, the more room for error in aggregation in the report (see Chapter 6).
5) **Lack of motivation and incentive.** CHWs are not compensated for submitting correct report data, nor are they routinely given feedback on them. If there is no accountability for poor data quality, there may be no reason to take the time to aggregate data accurately.

Recommendations and actions for improving data quality

At the time of study, the MoH and PIH were actively responding to some of these issues in an effort to address the resulting poor data quality.

Systems factors

To solve the problem of availability of recording tools, implementing partners should support the MoH to strengthen standardized procedures to ensure reliable re-supply of printed tools at the district, health center, and CHW levels. As an example, one NGO-supported initiative – SC4CCM (supply chain for community case management) – has developed tools and training materials for cell-level CHW coordinators to manage iCCM medications and other supplies from health center to CHWs (John Snow Inc. (JSI), 2013). Printed materials should also be included in this process.

The MoH revised their national health management information system indicators, and as part of this process, revised their monthly report including improved indicator definitions with clear instructions for completion, and accommodation for the new fever testing and treatment protocols by CHWs. This should contribute to better understanding of the indicators at all levels.

Similarly, iCCM tools have been revised based on the new treatment protocols (including integration of RDT activities) and an effort was made to improve both the sick child management form and register to facilitate simple and accurate recording, matching of data elements from forms to registers, and tallying into the monthly report. Despite this, data elements still do not match exactly across the form, register and report.

Neither CHWs nor any level of community health program supervisor (cell through district) receive any specific training on assessing or assuring data quality. Developing DQA tools and a simple training for each of these groups could encourage integration of data quality activities into supervision prior to aggregation to the next level. In the future, the data quality assessment carried out in southern Kayonza could be modified to be carried out by supervisors on a quarterly or biannual basis (see below). Training should be linked closely to supervision – supervisors should assess CHW data quality at routine supervision visits and immediately address incomplete, inaccurate or unreliable data. The MoH with partners is currently developing standardized tools, structures and trainings for community health supervisors at all levels, and it is feasible to integrate routine data quality assessments into these developments.

CHW factors

In lieu of iCCM refresher trainings, the MoH began performing individual CHW evaluations on their ability to implement iCCM, including recording information, followed by on-the-spot training as necessary. This would better identify CHWs with limited literacy or numeracy, comprehension of the original training and mastery of iCCM tools recording and reporting.

To address the lack of motivation and incentive, in addition to support through supervision and training, incorporating a measure of data quality into the PBF system would ensure CHW accountability and may therefore improve the aggregated information on the monthly reports.

The link between certain CHW and program factors and data quality is explored in more depth in Chapter 6.

To specifically address poor data quality, we additionally advise ongoing data quality (reliability) assessments to be integrated into routine activities, utilizing the well-developed structure of Rwanda's CHW program, as Mphatswe et al. (2012) did to successfully improve facility-level data in South Africa. For example, a data quality checklist can be developed for routine supervision visits to provide specific guidance and a forum for feedback around areas needing improvement. We believe strengthening the supervision process will lead to improved data quality (Admon et al., 2013; Hedt-Gauthier et al., 2012; Helleringer et al., 2010; Makombe et al., 2008). We also advise carrying out external reliability assessments biannually, adapting the LQAS-based system described in this study with possible modifications addressed below to identify health center catchment areas with ongoing poor data quality that will be targeted for additional trainings of CHWs and supervisors. Health center and district supervisors, who have at least a high school education, can be trained to carry out these assessments with the aid of partners and central-level MoH supervisors. In Malawi, Admon et al. (2013) found that CHW supervisors (with more training and fewer external demands on their time) were able to produce better quality reports (more reliable data aggregation). Rwanda could similarly shift the task of completing the monthly village report to the cell supervisor, though at the time of this study (outside of PIH-supported districts), these supervisors did not receive any more training but have more program demands on their time than CHWs.

Regardless of the intervention(s), the goal is that improvements in completeness and consistency of data will contribute to enhanced data utilization at all levels of the health system (Aqil et al., 2009; MEASURE Evaluation, 2010, 2012; Nutley, 2012).

LQA-based routine data quality assessments: possible adaptations

Threshold selection

A report was defined to be of 'poor' quality if the results did not match exactly as even small errors on a single report can be of great concern when the reported value is commonly small. This difference could magnify with each level of aggregation, seriously undermining the validity of national level figures. This is illustrated by SKHC1 in southern Kayonza, where the village monthly report and register differences for the pneumonia indicator were less than one, but the totals across the villages differed by 18% (22 in the reports and 18 in the registers). These errors are greater for the fever indicator as health center totals from registers were zero for all but one health center catchment area; yet, report totals ranged from seven to 51 for the same indicator (86-100% difference). On a district level, the absolute differences in the fever indicator tallies are substantial (see Table 20). However, if an indicator has commonly larger values (as with total sick children indicator), it may be more useful to define a report of 'good' quality so long as the reported number is within a certain percentage or range of the true value; e.g. +/- 1 or 5%. For example, Makombe et al. (2008) defined data accuracy as ≤5% difference between facility reports and supervisor reports in Malawi's national HIV treatment program.

The thresholds for ‘good’ and ‘poor’ report quality were based on discussions with PIH. However, the most meaningful thresholds for the national program may differ depending on the intended application of the data. In Kenya, CHW data with 90% agreement were assessed to be adequate for local program planning and action, but not to guide higher level policy (Otieno et al., 2011).

Lowering the thresholds, especially when overall data quality is low, will identify additional variability; for example, at the current 70%/90% thresholds, seven of the eight health center catchment areas are classified as having ‘poor’ data quality for the total sick children indicator in southern Kayonza. Changing the thresholds to 60%/80% (d=4 to d=6) would result in only four of the eight being classified as having ‘poor’ data quality, better identifying the health center catchment areas with the worst data quality challenges. Further, identifying fewer prioritized areas for improvement would increase the feasibility of the follow-up training activities. Alternatively, maintaining thresholds optimal for program management may demonstrate future improvements. For example, in a concurrent study in Malawi, authors applied a similar methodology with the same thresholds (70%/90%) and found reliability of CHW reports to be 56-75% pre-intervention, but >90% post-intervention (Admon et al., 2013).

Indicator selection

Indicators for this study were selected by PIH applying the following parameters: 1) report data element with corresponding field in forms and registers; 2) high priority for program management; and 3) high enough volume that indicator is typically non-zero during reporting period. However, treatment rates were lower than expected in Kirehe where on average, each CHW reported seeing between one to two sick children per month; thus, we observed many zero values particularly for the pneumonia indicator which tended to be consistent across reports and registers and therefore more concordant.

Logistical considerations

For some villages in southern Kayonza, the indicators did not always match between the forms and the registers suggesting some error in transcribing data between them. However, for future iCCM reliability assessments in Rwanda, comparisons of reports to the registers *only* are sufficient for determining reliability of the report data, saving time and resources, and permitting regular external assessments.

CHWs were requested to travel to the health center with forms, registers and reports. For health center catchment areas with ≤25 villages, there was little resource efficiency gained in sampling 19 rather than taking all villages. We believe that routine reliability assessments for one health center catchment area should be completed in one day by two evaluators and propose the following strategy: 1) health center catchment areas with ≤25 villages examine all reports; 2) health center catchment areas with >25 villages randomly sample 19 (d=4) (for 31-64 villages) or 25 (d=5) (for ≥65 villages) per classification constraints (Appendix 10.9). Revision of this strategy may depend on CHW patient burden, whether comparing with registers only or with registers and forms, and the speed of data collection. Additionally, by taking all village reports (a census) in four health center catchment areas in southern Kayonza and comparing these results to an equivalent

LQAS sample, we were confident that the parameters we defined would result in accurate classifications.

Strengths

This study had several strengths. Firstly, it employed a simple and practical methodology (LQAS) that can be replicated by program managers and supervisors to routinely assess CHW data quality over time; classifications of 'good' versus 'poor' quality data are both easy to understand and measure (improvement). Secondly, the assessment focused on data collected in a program that is being implemented globally to reduce U5 mortality (iCCM), filling a need to address monitoring concerns within iCCM (George et al., 2012a; WHO/UNICEF, 2012). Thirdly, the results of this study add to a nascent body of literature measuring quality of data collected and reported by CHWs – particularly as these data are increasingly used for program monitoring, management and evaluation at all levels. Finally, PBF systems are also gaining popularity in low-resource settings, though with mixed results (Ireland et al., 2011; Witter et al., 2012); yet, there are few studies examining community-level PBF systems outside of Rwanda (Basinga, 2011). The results of this study provide insight into the potential for purposeful misreporting within such a system.

Limitations

One limitation of this study is there was potential data collection and transcription error on the part of the data officers; this may have in turn led to an incorrect classification of data quality. For future assessments, those involved in data collection must maintain a high level of rigor and receive the training necessary to produce the LQAS data quality classifications. A paper-based tool currently under development can support extraction and classification, simplifying field implementation and removing one level of transcription from the process.

Secondly, the study did not quantify types and counts of data recording and reporting errors (e.g. completeness, incorrect entries in registers or forms, etc.). However, data officers reported observations and took digital photos highlighting examples of the most common errors that were seen, including inconsistent recording (e.g. 'Y' , '√', 'X', 'O' to all mean 'yes'), incomplete recording (blanks) and illegible recording. These observations were communicated to and discussed with the MoH during dissemination of the study results to inform future action.

Finally, CHWs submitted their monthly village reports on various days of the month depending on their health center or cell. This ranged from the 23rd to the 30th of the month. As a result, reporting periods did not exactly align with a given month. For example, April reports started anywhere between March 23rd-30th and ended anywhere between April 22nd-29th, and depended on the health center, cell or village of the CHW. Without standardized reporting periods, it was difficult to ascertain which forms and register entries made it into the monthly report.

Generalizability

This study was carried out in three districts in Rwanda, where the national community health program is well-organized and structured: there is a delineated supervision structure at every administrative level (from cell to health center to district and central levels) where information passes through on designated dates and in theory, there is a feedback mechanism; all tools are standardized which makes evaluating data quality much easier across sites; and finally, CHWs in Rwanda are accountable to the program through regular supervision and meetings, occasional evaluations and the PBF system. Finally, the CHW program has political will to support and improve the program on an ongoing basis. As a country that has led the way in innovative CHW programs, these factors may be unique to Rwanda's national CHW program; nevertheless, Rwanda may rather serve as a model to other countries, and these specific characteristics do not prevent other programs from carrying out a similar data quality assessment and acting on those results at any scale, given resource availability.

While the study only reflects classifications from three [hospital] districts of approximately 40 in Rwanda, we purposefully selected districts with varying levels of partner support present in the country, making the results largely applicable to all districts.

Similarly, this study only looked at data from one program (iCCM) and one type of CHW (*binôme*). However, the iCCM program is one of the more resource-intensive in Rwanda and warrants more in depth understanding of data quality, particularly in light of better measurement of important child health indicators (WHO, 2011) and the importance of iCCM as a global strategy for achieving reduced child mortality (WHO/UNICEF, 2012). Additionally, the program uses algorithms and tools adapted from a generic set of guidelines thereby making these results potentially useful for other countries also implementing iCCM programs. Regarding applicability in Rwanda, maternal health CHWs have similarly structured data collection and reporting tools that could also be assessed for data quality.

This study looked at only one component of data quality of the CHW monthly village reports – reliability; however, there are other aspects of concern, including timeliness, completeness, confidentiality and accuracy. The PBF system provides CHWs financial incentive to submit complete and timely reports. Therefore, as De Naeyer (2011) shows in his presentation of data from the community PBF system in Rwanda, measuring the completeness and timeliness of the monthly reports would have resulted in an almost 100% compliance rate. Further, treatment indicators are not included as part of the PBF system in order to prevent perverse incentives (De Naeyer, 2011). As noted in the introduction, a study by the authors looking at accuracy of CHW data collected during routine household visits found that it was largely good. The results of this study provide a more complete picture of CHW data quality in Rwanda, which will enable PIH with the MoH to interpret results and address gaps identified.

Conclusion

This study demonstrated gaps in data reliability within the iCCM program in Rwanda. However, we also suggest potential reasons and ways in which to address these issues to improve overall CHW data quality, many of which the MoH and PIH are actively implementing. Further, we believe the act of conducting ongoing assessments in itself can improve data reliability and use and can identify areas needing additional support. The lessons learned, recommendations and data quality assessment methodology extend to other CHW programs in Rwanda, and more globally – particularly to other iCCM programs -- and utility of these data for health program management, evaluation and quality assurance. Finally, more rigorous evaluations of factors related to CHW data quality may confirm or complement our anecdotal observations, leading to more pointed policy implications for all CHW programs.

5.6 *Tables and figures for Chapter 5*

Figure 4. Flow of data in the iCCM program within SISCom

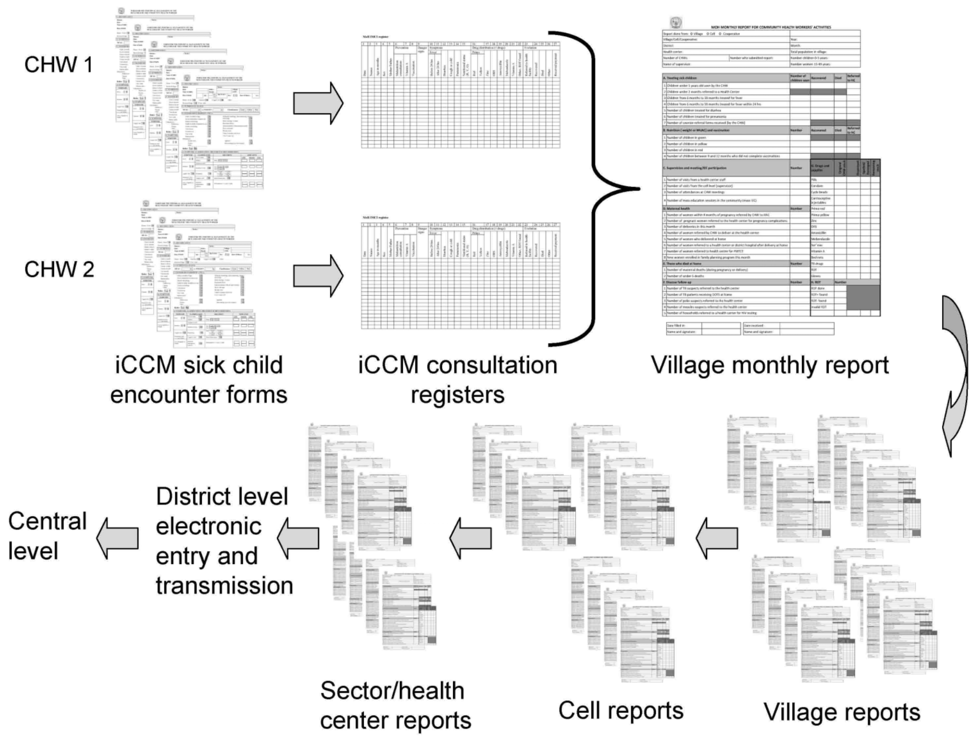


Table 14. Classification of data reliability comparing monthly reports to registers and forms by health center catchment area and indicator for southern Kayonza district

Indicator		**# total children seen**		**# children 6-59 mos treated for fever <24hrs and referred**		**# children with pneumonia treated and recovered**		**Composite**	
Health Center	# monthly reports	# not match-ing	Classifi-cation	# not match-ing	Classifi-cation	# not match-ing	Classifi-cation	# not match-ing	Classifi-cation
Comparison of monthly reports to registers									
SKHC1	19	11	Poor	3	Good	6	Poor	12	Poor
SKHC2	19	8	Poor	2	Good	7	Poor	10	Poor
SKHC3	19	2	Good	13	Poor	7	Poor	16	Poor
SKHC4	19	12	Poor	6	Poor	7	Poor	16	Poor
SKHC5	19	6	Poor	8	Poor	6	Poor	12	Poor
SKHC6	19	7	Poor	17	Poor	5	Poor	18	Poor
SKHC7	7	2	Poor	5	Poor	2	Poor	6	Poor
SKHC8	18	7	Poor	9*	Poor	2	Good	14*	Poor
Comparison of monthly reports to forms									
SKHC1	19	13	Poor	3	Good	5	Poor	14	Poor
SKHC2	19	8	Poor	3	Good	5	Poor	9	Poor
SKHC3	19	5	Poor	13	Poor	7	Poor	16	Poor
SKHC4	19	11	Poor	6	Poor	6	Poor	15	Poor
SKHC5	19	8	Poor	8	Poor	3	Good	11	Poor
SKHC6	19	8	Poor	17	Poor	1	Good	18	Poor
SKHC7	7	3	Poor	5	Poor	4	Poor	6	Poor
SKHC8	18	8	Poor	9*	Poor	1	Good	13*	Poor
* one less report in sample due to missing data in report									

Table 15. Classification of data reliability comparing monthly reports to registers by health center catchment area and indicator for northern Kayonza district

Comparison of monthly reports to registers		**# total sick children seen**		**# children with fever treated and referred**		**# children with pneumonia treated and recovered**		**Composite**	
Health center	# monthly reports	# not match-ing	Classifi-cation	# not match-ing	Classifi-cation	# not matching	Classifi-cation	# not match-ing	Classifi-cation
NKHC1	19	16	Poor	1	Good	7	Poor	17	Poor
NKHC2	7	3	Poor	4	Poor	4	Poor	6	Poor
NKHC3	19	4	Poor	2	Good	5	Poor	9	Poor
NKHC4	17	4	Poor	1	Good	8	Poor	11	Poor
NKHC5	19	0	Good	10	Poor	2	Good	12	Poor
NKHC6	19	8	Poor	5	Poor	5	Poor	13	Poor

Table 16. Classification of data reliability comparing monthly reports to registers by health center catchment area and indicator for Kirehe district

Comparison of monthly reports to registers		**# total sick children seen**		**# children with fever treated and referred**		**# children with pneumonia treated and recovered**		**Composite**	
Health center	# monthly reports	# not match-ing	Classifi-cation	# not match-ing	Classifi-cation	# not matching	Classifi-cation	# not match-ing	Classifi-cation
KIHC1	19	2	Good	8	Poor	1	Good	10	Poor
KIHC2	19	1	Good	2	Good	1	Good	3	Good
KIHC3	19	0	Good	10	Poor	1	Good	10	Poor
KIHC4	15	4	Poor	3	Poor	1	Good	7	Poor
KIHC5	25	3	Good	7	Poor	1	Good	9	Poor
KIHC6	19	2	Good	2	Good	1	Good	5	Poor
KIHC7	25	2	Good	8	Poor	1	Good	9	Poor
KIHC8	19	6	Poor	5	Poor	2	Good	9	Poor
KIHC9	19	4	Poor	2	Good	2	Good	7	Poor
KIHC10	19	3	Good	7	Poor	2	Good	10	Poor
KIHC11	19*	3	Good	0	Good	0	Good	3	Good
KIHC12	19	1	Good	8	Poor	3	Good	9	Poor
KIHC13	25	9	Poor	5	Poor	2	Good	12	Poor

*carried out data quality for all villages, but sampled 19 for LQAS exercise

Table 17. Point estimates and 95% confidence intervals (CI) of 'good' data reliability comparing monthly reports to registers by district and indicator

Comparison of monthly reports to registers	**District**		
	Southern Kayonza	Northern Kayonza	Kirehe
Indicator	**Estimate (95%CI)**		
# total children seen	59.3% (53.3%, 65.2%)	64.4% (59.0%, 69.7%)	84.9% (81.2%, 88.6%)
# children 6-59 months with fever treated and referred	57.5% (52.1%, 62.9%)	75.5% (69.7%, 81.4%)	72.3% (67.5%, 77.1%)
# children with pneumonia treated and recovered	71.0% (65.7%, 76.2%)	71.8% (65.9%, 77.7%)	93.4% (90.9%, 96.0%)
Composite	26.2% (20.7%, 31.6%)	31.8% (25.5%, 38.2%)	59.8% (54.5%, 65.0%)

Table 18. Health center classifications, point estimates and 95% confidence intervals (CI) of 'good' data reliability comparing monthly reports to registers by district and indicator

Comparison of monthly reports to registers	**District**					
	Southern Kayonza		Northern Kayonza		Kirehe	
# health centers	**8**		**6**		**13**	
Indicator	**# 'good'**	**Estimate (95%CI)**	**# 'good'**	**Estimate (95%CI)**	**# 'good'**	**Estimate (95%CI)**
# total children seen	1	59.3% (53.3%, 65.2%)	1	64.4% (59.0%, 69.7%)	9	84.9% (81.2%, 88.6%)
# children 6-59 months with fever treated and referred	2	57.5% (52.1%, 62.9%)	3	75.5% (69.7%, 81.4%)	4	72.3% (67.5%, 77.1%)
# children with pneumonia treated and recovered	1	71.0% (65.7%, 76.2%)	1	71.8% (65.9%, 77.7%)	13	93.4% (90.9%, 96.0%)
Composite	0	26.2% (20.7%, 31.6%)	0	31.8% (25.5%, 38.2%)	2	59.8% (54.5%, 65.0%)

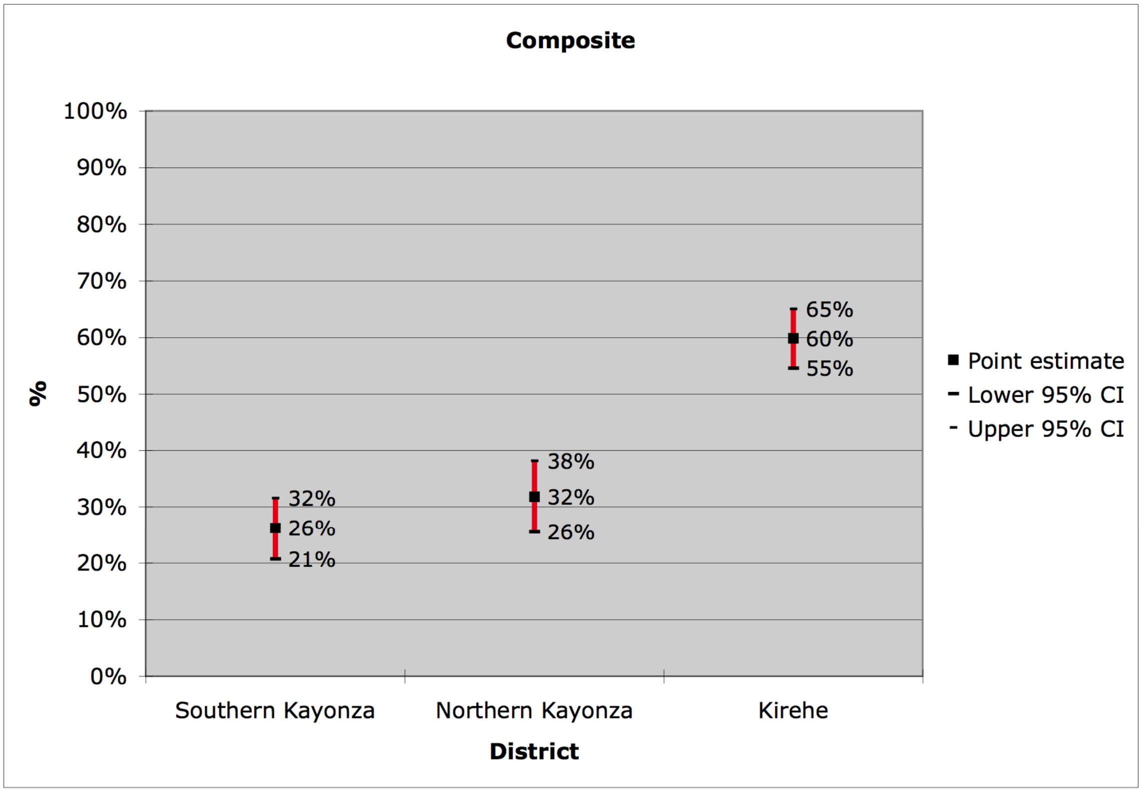
Table 19. Of discordant reports, percentage over-reporting, 95% CI and median difference, interquartile range (IQR) by district and indicator

	District					
	Southern Kayonza		Northern Kayonza		Kirehe	
Indicator	**% Reports > Registers (95% CI) / Median difference (IQR)**					
# total children seen	51.3% (41.4%, 61.2%)	1 (-1,1)	74.1% (64.9%, 83.2%)	1 (-1, 3)	64.2% (NA)	1 (-1,2)
# children 6-59 months with fever treated and referred	97.8% (94.4%, 100%)	3 (1,4)	89.2% (NA)	2 (1,3)	94.6% (89.1%, 100%)	2 (1,3)
# children with pneumonia treated and recovered	65.2% (55.1%, 75.2%)	1 (-1,2)	87.9% (79.6%, 96.2%)	1 (1,2)	33.3% (NA)	-1 (-1,1)

Table 20. District totals by indicator in reports and registers

	Total no. sick children seen		No. children with fever treated and referred		No. children with pneumonia treated and recovered	
District	**Report**	**Register**	**Report**	**Register**	**Report**	**Register**
Southern Kayonza	1126	1087	206	1	321	291
Northern Kayonza	686	664	61	3	225	189
Kirehe	884	847	179	14	116	119

Figure 5. Point estimates and 95% CI of composite indicator for 'good' data reliability of reports compared to registers by district



Chapter 6. “Factors associated with quality of community health worker data in Rwanda” (Manuscript 3)

6.1 Abstract

Background: Community health workers (CHWs) collect and report on much data through program and country health information systems; however, these data are of variable quality. It is important to understand what factors might be related to data quality in order to better address improving it, and thereby allowing stakeholders to more confidently use these data for program monitoring, evaluation and management.

Objectives: Examine key CHW and program factors, including level of program support, time since and type of training, level of education of CHW, time as CHW, and level of supervision, associated with accuracy in southern Kayonza district, and reliability of CHW data in Kirehe, southern and northern Kayonza districts in Eastern province, Rwanda.

Methods: Data officers administered a structured interview to CHWs across the three districts from October, 2011 to April, 2012, including questions on sociodemographic characteristics, history of CHW activities, training and supervision. We used logistic regression to measure associations between these independent variables (CHW and program factors) and dependent binary variables (yes/no): accuracy of household registers and reliability of village-level monthly reports, measured previously for a random sample of CHWs.

Results: A total of 204 CHWs and 1,224 households for the accuracy part of the study and 1,177 CHWs for the reliability part were included in the final analysis. After adjusting for other predictors, whether the CHW logged a visit to the household in the last month in the household register was positively associated with data accuracy (OR: 1.71; 95%CI: 1.22, 2.39). Number of sick children seen in April 2011 was the strongest negative predictor of reliability, controlling for all other variables: CHWs seeing four or more sick children were more than 70% less likely (OR: 0.295; 95%CI: 0.191, 0.455) to have reliable data.

Conclusion: The analysis of CHW and program factors demonstrates opportunities for improving data quality, complementing prior anecdotal evidence. Further, the results provide a platform for understanding potential challenges in other settings where CHWs may have greater geographic regions and populations to cover. The lack of significance between any sociodemographic characteristics, training and supervision may have been due to homogeneity among CHWs and resulting small sample sizes. Future studies could look at the relationship between data quality and other unmeasured factors such as content and quality of training and supervision, time spent carrying out CHW activities, use of data, among others.

6.2 Introduction

Community health workers (CHWs) have become central to achieving global health objectives over the past few decades (health for all, Millennium Development Goals, universal health coverage) and addressing health sector human resource constraints (Bhutta et al., 2005; Bhutta et al., 2010b; CHW Technical Taskforce, 2013; de Sousa et al., 2012; Edward et al., 2007; Global Health Workforce Alliance, 2012; Hafeez et al., 2011; Haines et al., 2007; Lehmann et al., 2007; Liu et al., 2011; Perry et al., 2012; Prata et al., 2012; Schneider et al., 2010; United Nations, 2013; United Nations Statistics Division, 2012a; WHO et al., 2010; WHO/UNICEF, 2004a, 2004b; Young et al., 2012), by providing improved access to important health services at the community and household levels. As an integral part of the health system, CHWs necessarily engage in the monitoring and evaluation (M&E) of their activities as part of the broader health information system (HIS).

While a great volume of data is collected and reported by CHWs, these data are variable in their quality (accuracy and reliability). For example, authors in Pakistan measured fewer than half of monthly reports submitted by community-based Lady Health Workers to be accurate (Mahmood et al., 2010). Similarly, in Neno, Malawi, Admon et al. (2013) showed 25-44% of CHW reports pre-intervention to be unreliable depending on the indicator. Helleringer et al. (2010) found both over- and under-reporting to be common in an operational study looking at the quality of CHW data in one region of Ghana.

However, few studies have systematically linked what factors are associated with CHW data quality in order to improve it (Admon et al., 2013; Crispin et al., 2012); in Malawi, stakeholder interviews identified inadequate time, training and tools for data aggregation as potential contributors to poor data quality (reliability) (Admon et al., 2013). In Kenya, Crispin et al. (2012) report that age, sex and level of education were associated with CHW record-keeping. In addition, other studies cite anecdotal factors such as inadequate supervision, training and inappropriate or numerous data collection tools as potential contributors to poor data quality among CHWs (Helleringer et al., 2010; Mahmood et al., 2010).

The objective of this study is to understand the factors associated with CHW data quality (accuracy and reliability) in three districts in Eastern Rwanda. We use a conceptual framework adapted from the PRISM (Performance of Routine Information System Management) framework developed by Aqil et al. (2009) which links different sets of determinants to a functioning routine HIS, applicable to the community level (see Figure 1). The authors group these determinants into three: 1) technical (related to the design and technology of the overall HIS); 2) organizational (related to the health service delivery context); and 3) behavioral (influenced by the first two and are related to ability of health workers to carry out HIS tasks). These factors form the inputs of the framework, which subsequently influence the various HIS processes (data collection, transmission, analysis, feedback), outputs (improved HIS performance), outcomes (improved overall health system) and impact (improved health outcomes).

Applied to the community level HIS, this study takes one category of these primary determinants – organizational factors – and further breaks them down into CHW and program factors. Other factors are therefore outside the scope of this study but would be important to look at in future research.

Study setting

Rwanda relies on some 45,000 CHWs to carry out preventive and curative activities in their villages (Mugeni, 2012). In each village (roughly 50-150 households), there is a maternal health CHW who monitors pregnant women and their newborns, and at least two multi-disciplinary CHWs (*binômes*) who carry out: 1) community integrated management of childhood illnesses (iCCM) (assessment, classification and treatment or referral of diarrhea, pneumonia, malaria and malnutrition in children under five years of age); 2) malnutrition screening; and 3) other preventive and behavior change activities (MoH [Rwanda], 2011b; Mugeni, 2011). Supervisors at the cell (~10 villages), health center (~5 cells) and district levels (~10 health centers) oversee CHW activities on a regular basis. For each activity, there are corresponding standardized data collection tools and a monthly report comprising the national community health information system (*Système d'Information de la Santé Communautaire* or SISCom) (MoH [Rwanda], 2008b). Consequently, CHWs collect and report a large amount of data through SISCom.

However, while we presented results showing that CHWs were able to accurately collect household-level data in Chapter 4 (concordance between CHW household register and household interview and client-held cards) in one district in Rwanda (Mitsunaga T & Hedt-Gauthier B et al., 2012b), we also found that village-level monthly report data were not well-aggregated (or reliable) within the iCCM program (concordance between iCCM consultation register and report tallies) in three districts (Chapter 5) (Mitsunaga T & Hedt-Gauthier B et al., 2013). Therefore, it is important to understand what program and

CHW factors might be specifically related to these two components (accuracy and reliability) of data quality in order to better address improving it, and thereby allowing the government to more confidently utilize these data for program monitoring, evaluation and management.

This particular study was carried out in southern Kayonza, northern Kayonza and Kirehe districts in Eastern province, Rwanda. The total catchment area is roughly 540,000 persons. The international non-governmental organization Partners In Health (PIH) supports the full Ministry of Health (MoH) implementation of the CHW program in southern Kayonza district in addition to enhancements in supervision, monitoring and evaluation (M&E), data use, compensation and trainings. *Binômes* in the PIH catchment area also provide a range of care extending to the entire household, beyond iCCM for children under five years of age (U5) including monthly household visits and the use of a community health household register to collect key data, including information on basic demographic characteristics of all household members and key data on target populations such as U5 children and women of reproductive age (Drobac et al., 2013). Another partner, IRC (International Rescue Committee) provided technical and financial support to the iCCM program in Kirehe at the time of research. This included support around M&E, training and quality improvement of iCCM activities. EGPAF (Elizabeth Glaser Pediatric AIDS Foundation) supported HIV-related activities in northern Kayonza.

All *binômes* and cell supervisors should receive a four-day iCCM training including how to fill out the forms and registers (with annual refresher trainings thereafter), and a one-day training on how to fill out the monthly report. In southern Kayonza, *binômes* and cell supervisors received a one-day training on the household register. Trainings and monthly meetings are held at the health center and overseen by the community health supervisors at that level.

This study focuses on data collected and reported by *binômes* (hereafter "CHWs") for their iCCM activities (reliability) and monthly household visits (accuracy) and individual characteristics of these CHWs as well as general program-related factors.

6.3 Methods

Sampling

We used Lot Quality Assurance Sampling (LQAS) to measure and classify data accuracy in CHW household registers by cell catchment area and reliability in CHW village-level monthly reports by health center catchment area. For this study, our sampling frame was all CHWs who were included in the previously conducted accuracy and reliability studies.

For the accuracy study, based on pre-determined thresholds for 'good' and 'poor' data accuracy, we randomly sampled six CHWs in each of the 34 cell units in southern Kayonza for a total of 204 eligible CHWs.

The sample for the reliability study was selected using LQAS and is described by Mitsunaga & Hedt-Gauthier et al. (2013). In brief, we randomly sampled villages by health center catchment area based on pre-determined thresholds for 'poor' and 'good' data reliability. For health center catchment areas with ≤25 villages, we took a census; for those with 26-64 villages, we randomly selected 19; and for health center catchment areas with >65 villages, we selected 25.

The reliability study sample included 200 CHWs in northern Kayonza, 477 in southern Kayonza and 526 in Kirehe for a total of 1,203 eligible CHWs.

Data collection

Data officers administered a pre-tested structured interview to all sampled CHWs who were present at the time of the reliability studies in northern Kayonza (March to April, 2012) and Kirehe (October to November, 2011). For both the accuracy and reliability study samples in southern Kayonza, we extracted this information from a pre-existing database of all eligible CHWs. These data were collected from October 2011 to January 2012 as part of program monitoring purposes and were stored at PIH, Rwanda. We used the same questionnaire for all CHWs. Data officers entered information directly into an Access database on a laptop if electricity was available at the health center; if not, they completed a paper form which was subsequently entered into the database.

While personal identifiers such as name, date of birth, sex, village and cell were collected during the interviews, all analyses were conducted at the district or health center level to protect individual identification of the CHW.

Dependent variables

The main dependent binary variable for data accuracy is the composite indicator defined as discordance between the CHW household register entries and information gathered during the household visit for any one of the five individual indicators (number of children under five years; number of women 15-49 years; number of home deliveries; number of women on modern family planning method; type of modern family planning method) (not accurate) or concordance on all five (accurate). The analysis was carried out at the household level adjusting for clustering between households within the same CHW catchment area.

The main dependent binary variable for data reliability is the composite indicator -- defined as discordance between the iCCM consultation register and April 2011 monthly village report on any one of the three individual (fever, pneumonia, total sick children seen) indicators (not reliable) or concordance on all three (reliable). The analysis was carried out at the CHW level, adjusting for clustering between CHWs within the same health center catchment area.

Independent variables

We categorized independent variables (see Table 21) into two groups: 1) CHW characteristics including age in years, sex (male/female), level of education (incomplete primary, complete primary, any secondary and higher), occupation (farmer, other/none/missing), number of living children and civil status (single, married or cohabiting, separated, divorced, widowed; and 2) CHW program characteristics including frequency and duration of cell and health center supervision visits (None, 1-2 times >2 times, <30 minutes, 30-60 minutes, >60 minutes), iCCM, monthly report or any training received in the last six months or ever, sector cooperative membership (yes/no), type of CHW (*binôme*/cell coordinator), walking distance from home to health center (in minutes), number of households in catchment area, number of sick children seen in April, 2011 (0, 1, 2, 3, 4 or more) and number of years as CHW with a spline at six years.

After the pilot was carried out in Kabarondo health center catchment area, we added three yes/no questions to the household register survey: 1) CHW recorded a household visit within the last month (List 9) (as a measure of CHW performance – we assumed that if the CHW recorded having visited the household in the previous month in the household register, s/he updated all other relevant lists at the same time); 2) CHW stored household register in program-provided wooden box; and 3) CHW kept wooden storage box locked. However, as these variables were only included after the pilot, data from Kabarondo health center catchment area are missing (n=144).

We tested all independent variables for normalcy and recategorized or added a spline term to them according to best fit. We considered potential measured confounders and effect modifiers.

Age, if missing, was imputed from year of birth. Number of households and number of sick children seen in April 2011 were transformed from continuous into categorical variables, and we added a spline term for age at six years due to improved fit.

Analysis

We carried out the analysis using Stata statistical software version 10 (StataCorp, 2007).

Descriptions of CHW and program factors included means (continuous) or proportions (categorical) with 95% confidence intervals and P values using the chi square test for categorical variables and F test adjusting for clustering with continuous variables. Analyses were done combining all districts for accuracy and reliability and also separately by district and dependent variable.

We compared baseline characteristics across districts and among CHWs with reliable and not reliable data and accurate and not accurate data to understand how these three groups differed and how that might affect generalizability.

We dichotomized the dependent variables as binary variables where Y=0 and Y=1 and Y is the composite indicator for reliability or accuracy. For all outcome variables, we used logistic regression analysis and resulting odds ratios to determine associations between the probability of accuracy and reliability (Pr) and $X_{1\ldots}$CHW or program factors listed in Table 21 using the following formula:

$$\text{Logit}[\Pr(Y=1)] = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\ldots$$

Where,

X_1 = Level of program support

X_2 = Level of supervision

X_3 = Level of training

X_4 = Time spent as CHW

… = Other relevant program factors, confounders and effect modifiers

We fit univariate and multivariate logistic regression models separately for each dependent variable (accuracy and reliability) to examine the associations between them and CHW and program factors. We used the Hosmer-Lemeshow test for goodness-of-fit (not shown) to determine fit of the models. We determined collinearity by running separate multiple regression analyses to calculate variance inflation factors which were all below 10. We found ever having monthly report training to be very collinear with district and we therefore excluded it from the final reliability model.

We accounted for all measured confounders and effect modifiers as relevant based on previous study findings including other program factors. We used generalized estimating equation (GEE) models with robust standard error estimates to account for intraclass correlation (ICC) that may have been present between CHWs of the same health center catchment area when analyzing data quality of iCCM and registers and between households of the same CHW catchment area for the accuracy dependent variable.

We included all variables with $p<0.1$ in the adjusted model, but also carried out backwards stepwise regression.

6.4 Results

Accuracy

A total of 204 CHWs and 1,224 households were included in the accuracy study (100% of those eligible). Overall, 825 household entries had 'good' accuracy and 399 had 'poor' accuracy.

Descriptive analysis

There was little variation in sociodemographic characteristics among CHWs in the accuracy study in southern Kayonza. The median age was 36 years, with a little over half being male. Most CHWs were married or cohabiting (84.8%) with a median of four living children. Almost three quarters had completed primary education, and almost all reported farming as their primary occupation. Roughly 10% were members of the cooperative committee and had been CHWs for a median of four years. CHWs had an average of 56 households in their catchment areas with a mean walk of just over 1.5 hours to their health center. Roughly three quarters received at least one visit from the health center in the last quarter, and just under 90% received a visit from their cell supervisor in the last month. The duration of these visits varied, with about half of CHWs receiving visits 30-60 minutes long. Roughly one third of CHWs had received iCCM training in the last six months, and almost all of them had ever received it. Conversely, only one CHW had ever received a monthly report training (this may be a reporting error given that CHWs generally receive training at the same time by health center). While almost all of the CHWs kept their household register in the wooden lock box they received as part of the national program, only 61.1% kept the box locked. Finally, all but two of the health centers had four or five cell supervision catchment areas: Rutare only had one, and Rwinkwavu had seven.

Crude and adjusted models

Only three variables were significant at the $p<0.1$ level in the crude analysis with data accuracy. Compared to Ndego health center, only Ruramira had 1.61 times the odds of more accurate data (95%CI: 0.925, 2.79). After adjusting for all other predictors, Ruramira remained significantly associated with increased odds of data accuracy compared to Ndego (OR: 1.84; 95%CI: 1.07, 3.16), and Kabarondo became significantly associated at the $p<0.05$ level as well (OR: 2.30; 95%CI: 1.32, 3.99). Otherwise, ever having received monthly report training was positively associated with data accuracy in both the crude and adjusted models (OR: 4.89; 95%CI: 3.28, 7.30) though the sub-sample of CHWs who did receive the training was very small (n=1), likely due to misreporting (see above). Finally, whether the CHW logged a visit to the household in the last month in the household register increased odds of accurate data 1.71 times (95%CI: 1.22, 2.39) in the adjusted model. Removing ever receiving monthly report training from the adjusted model slightly attenuated the coefficients of the other two variables, though each remained significant (results not shown).

Reliability

A total of 471 CHWs in southern Kayonza, 180 CHWs in northern Kayonza and 526 CHWs in Kirehe (n=1,177) were included in the final analysis for the reliability study. Overall, 475 CHWs had ‘good’ data reliability and 702 had ‘poor’ data reliability defined by the composite indicator.

CHWs across districts differed slightly by civil status and occupation, while all other sociodemographic characteristics were similar. CHWs did differ by program variables including cooperative committee membership, mean number of years as CHW, mean number of households in CHW catchment area, mean walk to health center in minutes, mean number of sick children seen in April 2011, frequency and duration of cell and health center supervision visits received, and monthly report training ever received (see Table 24). Missing values were coded for supervision received. In other instances, they were excluded.

The mean age of CHWs was 38.5 years with slightly less than half of CHWs being male. The majority of CHWs were married or cohabiting (89.5%), had completed primary education (69.4%), and who had farming as a primary occupation (97.0%). Roughly 10% were a cooperative committee member, and 4% were cell coordinators. The mean number of years as a CHW was five with variation by district (4.1 in southern Kayonza to 5.8 in Kirehe). CHWs were responsible for an average of 50.7 households, but again, this ranged from a low of 36.7 in Kirehe to a high of 77.4 in northern Kayonza. Similarly, while the mean walk in minutes from CHWs' homes to the health center was 103.8, CHWs in northern Kayonza lived much farther away (163.1 minutes) than those in either of the other two districts. Correspondingly, CHWs saw on average more sick children in April 2011 (3.5) than in southern Kayonza (2.3) or Kirehe (1.6). The majority of CHWs received at least one cell supervision visit in the last month (79.7%) and at least one health center supervision visit in the last quarter (67.8%). However, 20.4% did not receive any cell supervision visits and 14% did not receive and health center supervision visits.

In terms of training, the majority of CHWs (82.5%) received iCCM training in the last six months, and almost all (96.5%) had ever received it. In contrast, fewer than half (41.7%) of CHWs had received any monthly report training ever and in southern Kayonza, nearly none had. Overall, almost all CHWs had received any training in the last six months.

Crude and adjusted models

Table 25 shows crude and adjusted odds ratios and 95% CIs for all independent variables. None of the CHW characteristics were statistically significant at the $p<0.05$ level whereas CHW program variables including district, number of years as CHW, number of households in CHW catchment area, number of sick children seen during April 2011, having received iCCM training in last six months and monthly report training ever were statistically significant at the $p<0.05$ level in the crude analysis for the reliability dependent variable. All variables (with the exception of ever having monthly report training as it was collinear with district) with $p<0.1$ in the crude analysis were included in the adjusted model. District and number of sick children seen in April 2011 were the strongest predictors of reliability: controlling for all other variables in the model, CHWs in northern Kayonza were more than twice as likely (OR: 2.55; 95%CI: 1.33, 4.88) to have reliable data than CHWs in southern Kayonza, and Kirehe CHWs were more than six times as likely (OR: 6.30; 95%CI: 3.42, 11.6). Additionally, the more sick children recorded being seen in April 2011 by CHWs, the worse the data reliability so that with one sick child, holding all other variables constant -- CHWs were more than a third less likely to have reliable data (OR: 0.609; 95%CI: 0.423, 0.877); with two sick children, they were about half as likely (OR: 0.478; 95%CI: 0.262, 0.869); with three sick children, they were almost two thirds less likely (OR: 0.371; 95%CI: 0.230, 0.596), and with four or more sick children, they were more than two thirds less likely (OR: 0.283; 95%CI: 0.180, 0.445) to have reliable data. Finally, adjusting for all other variables in the model, the farther a walk from the health center, the worse the data reliability (OR: 0.997; 95%CI: 0.994, 0.999) – for every minute away from the health center, the odds that data were reliable decreased by 0.3%. All other variables were no longer significant at the $p<0.05$ level in the adjusted model.

This model was cross-validated with a p-value of 0.5907 using the Hosmer-Lemeshow goodness-of-fit test. Including variables that were only significant at a $p<0.05$ level (via a step-wise approach) led to poor goodness-of-fit models.

Southern Kayonza

Results were similar when analyzing the reliability dependent variable by district. In southern Kayonza in the crude analysis, the greater number of years as CHW (OR: 1.06; 95%CI: 1.02, 1.11) and number of households in CHW catchment area (OR: 1.03; 95%CI: 1.00, 1.05) (though this is the reverse of what we saw in the other district models), the more likely the data were reliable. Conversely, the longer it took the CHW to walk to the health center (OR: 0.995; 95%CI: 0.989, 1.00) and the more sick children seen during April 2011 (OR: 0.803; 95%CI: 0.625, 1.03), the less likely the data were reliable. Additionally, if the CHW was a cell coordinator, s/he was more likely to have reliable data than if s/he was a *binôme* (OR: 1.89; 95%CI: 0.885, 4.04). Finally, any training received was negatively associated with data reliability (OR: 0.399; 95%CI: 0.242, 0.658), though the number of CHWs never receiving training was only five out of 471.

As with the all-district model, the adjusted model included all variables significant at the $p<0.1$ level in the crude models. This resulted in three significant predictors: holding the other predictors constant, the more time spent as a CHW, the better the data reliability (OR: 1.08; 95%CI: 1.02, 1.14); the more sick children seen in April 2011, the worse the data reliability – these results were similar to the all-district adjusted model, though the associations were only significant for three (OR: 0.317; 95%CI: 0.130, 0.773) and four or more children (OR: 0.206; 95%CI: 0.083, 0.510). Finally, while any training received remained significant when adjusting for other predictors, the relationship was the opposite of what we would hypothesize which may be a function of the small number of CHWs had not received any training (OR: 0.192; 95%CI: 0.107, 0.345). The Hosmer-Lemeshow goodness-of-fit test was p=0.438.

Northern Kayonza

In northern Kayonza, fewer predictors were significant at the p=0.1 level in the crude model. This included CHWs whose civil status was divorced/separated were more than two times likely than their married/cohabiting counterparts to have good data reliability (OR: 2.27; 95%CI: 1.26, 4.08). Number of sick children seen in April 2011 was also significant for one versus none (OR: 0.333; 95%CI: 0.148, 0.750) and four or more versus none (OR: 0.407; 95%CI: 0.173, 0.959). Finally, the number of households (categorical variable) was significantly associated with poorer data reliability at 36-60 households (OR: 0.417; 95%CI: 0.173, 1.00) versus <36 households.

However, the adjusted model fit poorly and therefore, we only present results for the crude model.

Kirehe

Civil status was the only statistically significant CHW characteristic in both the crude and adjusted models. Controlling for other predictors, single CHWs were more than eight times more likely to have good data reliability than married/cohabiting CHWs, though the confidence interval is very wide due to the small sample size (OR: 8.73; 95%CI: 1.53, 50.4). Other significantly associated program-related factors were similar to the all-district model: time to health center was inversely associated with data reliability so that adjusting for all other predictors, the odds of the data being reliable decreased for every minute farther the CHW has to walk to the health center (OR: 0.994; 95%CI: 0.990, 0.998); and the greater the number of sick children seen in April 2011, the worse the data reliability. Holding all other predictors in the adjusted model constant, the odds of good data reliability were reduced by about half with one sick child compared with none (OR: 0.532; 95%CI: 0.322, 0.880); 60% with two sick children (OR: 0.415; 95%CI: 0.190, 0.904); 67% with three sick children (OR: 0.330; 95%CI: 0.176, 0.617); and 72% with four or more children (OR: 0.280; 95%CI: 0.145, 0.541).

While the duration of last cell supervision visit was significant at the $p<0.1$ level in the crude analysis (<30 minutes), this predictor lost significance in the adjusted model. Similarly, while having received monthly report training the last six months was statistically significant in the crude model, it appeared to be completely confounded (went from positive to negative association) after being included in the adjusted analysis. However, having received iCCM training in the last six months was significant both in the crude and adjusted models (OR: 4.57; 95%CI: 1.55, 13.5) and was one of the strongest predictors even after adjusting for other variables, though the confidence interval was wide due to the small number of CHWs who received the training (n=25). The Hosmer-Lemeshow goodness-of-fit test was p=0.311.

6.5 Discussion

Only a few factors were associated with either CHW data accuracy or reliability in Rwanda, and these were related to the national program, rather than the individual CHW. We discuss possible reasons for these findings and how they may be applicable to Rwanda and other CHW programs. We then describe the strengths, limitations and generalizability of the overall study.

Data accuracy was associated with logging a household visit in the last month, controlling for health center and having received a monthly report training. This points to timeliness as well as completeness – others component of data quality – which appear to be associated with accuracy in this case. That is, if the CHW was diligent about completing the household register, the data tended to be accurate as well.

Above and beyond district, greater walking distance from the health center and patient volume were negatively associated with data reliability, controlling for other variables in the adjusted model (Table 25). This held true when the analyses were carried out by district.

Given our results in Chapter 5, it is not surprising that our analysis in this study showed that district was significantly associated with data reliability. More specifically, CHWs from Kirehe and northern Kayonza districts were able to aggregate their monthly reports more accurately than their counterparts in southern Kayonza district. While CHWs in both Kirehe and southern Kayonza received support from implementing partners (as discussed in Chapter 5), the difference in data reliability was likely due to the type of activities that were carried out: in the former, IRC provided targeted trainings and meetings to facilitate CHW recording and reporting whereas in the latter, PIH had additional reporting requirements without specifically addressing data quality. Furthermore, CHWs were allotted per household catchment area (roughly 50), and not by village as in Kirehe or northern Kayonza. This led to there being up to five CHWs in one village completing the same monthly report. We discuss in the limitations that we did not include number of CHWs per village in our analysis, though it may have been associated with data reliability (the more CHWs, the worse the data).

Unlike Crispin et al. (2012) who found that age, sex and level of education were associated with record-keeping in Kenya, we found no sociodemographic variables to be significantly associated with either data accuracy or reliability. These results may reflect a number of factors:

1) Selection criteria (age limit, minimum education level) for CHWs may be appropriate (i.e. may not affect data quality); or
2) Limited sociodemographic variability among CHWs with respect to occupation, civil status and education. With the exception of sex, CHWs were otherwise fairly

homogeneous: the majority were married or cohabiting, had completed a primary education and were with few exceptions, farmers. The range of CHW age and number of living children was also fairly narrow.

3) While there was more variability in education level than other sociodemographic characteristics, due to small sub-sample sizes, we grouped CHWs with any education above complete primary together. This ranged from a year to complete secondary education. In addition, even with a primary-level education, numeracy and literacy skills of some CHWs may not have been at a level at which was needed to carry out their tasks which was observed in Chapter 5.

With respect to program-related factors, it was surprising that neither training nor supervision variables were significantly associated with data reliability or accuracy in the adjusted models. However, this may again be a result of homogeneity across health centers for training (CHWs are trained by health center); or, it may be a result of the quality or content of the training rather than whether or not a training was received (as noted in Chapter 5). For example, for the monthly report training, this is presented orally (definitions of indicators), and there is not a practical component whereby CHWs may tally and complete the report using sample data sources (see Chapter 5). Likewise, while supervision may be carried out, our survey did not account for the quality or content of the supervision visits which may be as or more important. We know that supervisors in Rwanda did not receive any more training than the CHWs they supervised (e.g. how to provide supportive supervision). This may have limited the ability of supervisors to support good CHW data quality.

In the case of data accuracy, given that all CHWs received the same training on how to complete the household register, it appears that there is something above and beyond receipt of training that leads to timely recording that may not have been measured in this study (e.g. literacy or numeracy, motivation).

The independent variables significantly associated with data reliability may have broader policy implications for CHW programs in other countries. For example, the farther from the health center a CHW lived, the worse the data reliability. However, the median walking time was 90 minutes across all districts (150 in northern Kayonza). Rwanda is densely-populated, with relatively good access to health facilities. This may not be the case in other settings. Similarly, the more patients the CHW saw, the poorer the data reliability. Conversely, though non-significant in the adjusted model, greater CHW experience (number of years as CHW) was significantly associated with better data reliability. These results are similar to findings in the 2010 iCCM rapid evaluation that showed the more experience a CHW had implementing iCCM, the better the quality of care; however, the more presenting symptoms a child had, the worse the CHW adhered to treatment protocols (the more complicated, the worse the outcome) (MoH [Rwanda], 2011a). Again, where the median number of sick children seen per CHW during one month was one (two in northern Kayonza), the error in data aggregation may be multiplied given more patient volume in more remote places (poorer access to health facilities). In Ethiopia, for example, two health extension workers are responsible for a catchment area of 5,000 people (Health Systems 20/20 Project, 2012). This is almost ten times what CHWs in Rwanda cover (about 225 people).

Additionally, CHWs carry out more tasks than just seeing sick children (see Appendix 10.2) and accordingly, the monthly report includes data from several different programs. We looked at data aggregation for only one of these programs (iCCM), and did not measure the amount of time spent per day or week carrying out all CHW activities. One group has estimated this at roughly 85 hours per month or 50% of normal working hours, with six hours alone dedicated to reporting (GoR and partner) requirements (Health worker time allocation thematic working group, 2011)). It is possible that the greater the amount of time spent on CHW tasks, the worse the data quality pointing to competing demands on their time to carry out all program activities in addition to their primary occupation (farming). In their review of CHW effectiveness, Perry et al. (2012) state that, among other things, overburdening CHWs with activities and clients is a chronic problem in CHW programs which may affect their motivation. This was the case in Neno, Malawi, where Admon et al. (2013) found inadequate time to be associated with poor report data. Additionally, while CHWs are compensated through their cooperatives in Rwanda, the amount of actual income received can be variable and is pooled across up to 200 CHWs per sector. It is unclear what effect financial reimbursement to a group entity has on CHW motivation (which may in turn affect data quality).

Strengths

The results of this study fill a gap in the literature on factors related to CHW data quality. While there are several studies measuring different components of community level data quality, none went on to scientifically measure associations between data quality and potential independent variables. Further, this study looked at factors related to both accuracy and reliability of CHW data.

Limitations

As the national CHW program is well-structured and standardized, the selection criteria of CHWs and the way in which they are trained and supervised meant that some of these variables were homogeneous across CHWs (occupation, education level, civil status, cell supervision visit received and training received) and therefore may not have attained statistical significance in the analyses (previously discussed).

In addition, this study only focused on two measurable components of data quality – accuracy and reliability. There are others such as timeliness, completeness, etc. which may have had different associated factors. However, we would argue that accuracy and reliability are two of major components of data quality, without which, data use would not be desirable. In addition, CHWs in Rwanda are compensated through the PBF system in part for submitting complete and timely village-level monthly reports. According to De Naeyer (2011), measuring the completeness and timeliness of the monthly reports would have resulted in an almost 100% compliance rate. For factors related to accuracy, we attempted to include a measure of timeliness and completness (CHW logged household visit in last month) and confidentiality (CHW kept household register in locked wooden box), these secondary dependent variables; however, neither variable produced an adjusted model with adequate fit; we therefore included them as independent variables in the final accuracy model.

All but two of the independent variables were measured through CHW self-report. This may have lead to recall bias (inaccurate recollection of timing of last training and supervision received, and duration of supervision); or response bias (depending on program requirements, social context or other reasons, CHWs may have answered in the affirmative whether or not they received a supervision visit not wanting to make trouble for their superior). However, for the most part, there did not appear to be much room for bias among the questions in the survey.

Another limitation may be the difference in time when the questionnaire was administered to CHWs by district (October 2011 to April 2012). This six-month difference may have affected analyses for certain time-sensitive variables, mainly among the CHW program variables such as type of training received in the last six months or time as a CHW. This can be observed in Table 24 where the percent of CHWs receiving iCCM training in the last six months versus ever differs by district; and mean number of years as CHW is more than a year less in southern Kayonza than northern Kayonza. However, these variables would all be relative in the district-specific analyses.

Finally, we may not have included all possible factors associated with CHW data quality. For example, the number of CHWs completing the village monthly report was two with the exception of southern Kayonza where anywhere from two to five CHWs completed a single report. This may have in turn impacted the accuracy of aggregation (the more CHWs, the worse the data), though we did include district in the adjusted model (and southern Kayonza did have worse data reliability than either Kirehe or northern Kayonza). Another possible factor may have been time spent carrying out CHW-related activities per day or week. It might be that the more time spent, the worse the data quality, and that volume of patients may be one indicator of this. Finally, as noted previously, this study looked only at one type of factors – organizational – and others, namely technical and behavioral factors could certainly influence the quality of CHW data.

Generalizability

While these results are particular to Rwanda -- a country with a well-structured national CHW program including supervisors at all levels, a standardized community health information system, and an incentive system for CHWs – we showed that there are still weaknesses in the quality of both data accuracy and reliability as well as factors related to these which may be more universally applicable.

Similarly, regardless of the specific structure and components of a CHW program, if CHW data are being utilized for program monitoring, management, evaluation or quality assurance purposes, the data need be both reliable and accurate. This study provides evidence in one particular setting for what factors might be responsible for poor or good data quality, as well as recommendations for addressing them. Further, it informs what may be included in future similar studies in other settings.

Finally, other similar studies corroborate our recommendations for data-related training and supervision interventions to address these factors (Admon et al., 2013; Mphatswe et al., 2012).

Conclusion

This study provides the relevant inputs for the PRISM-based conceptual framework for data quality on which it is based: it complements findings from Chapters 4 and 5 measuring both data accuracy and reliability of CHW information in Rwanda (outputs) by analyzing possible CHW- and program- related factors (inputs) associated with data quality; and, together with the anecdotal observations discussed in Chapter 5, the findings present provide firm evidence for the Government of Rwanda to act on to improve data quality and the potential for data utilization at all levels, resulting in an overall strengthened health information system (outcome) and health sector (impact). We present recommendations following these results in Chapter 8.

6.6 Tables for Chapter 6

Table 21. CHW and program factors associated with quality of CHW data

Variable	Type of variable	Description
CHW variables		
Age of CHW	Continuous	CHW age at time of survey in years
Sex	Categorical	0=Male 1=Female
Civil status	Categorical	0=Married/ Cohabiting 1=Single 2=Divorced/ Separated 3=Widowed
Number of living children	Continuous	Number of children currently alive at time of survey
Level of education	Categorical	0=Incomplete primary or less 1=Complete primary 2=Incomplete secondary or higher
Primary occupation	Categorical	0=Farmer 1=Other (informal business, teacher, other), none, missing
CHW program variables		
Level of program support/ District	Categorical	0=PIH support (southern Kayonza) 1=No partner support (northern Kayonza) 2=Other partner support (Kirehe)
Membership on sector cooperative committee	Categorical	0=No 1=Yes
Type of CHW	Categorical	0=*Binôme* only 1=Cell coordinator
Number of years as CHW	Continuous / Spline	0-5 years >5 years
Number of households in CHW catchment area	Categorical	0=0-35 households 1=36-60 households 2=>60 households
Distance from health center	Continuous	Walking distance in minutes
Number of sick children seen as recorded in register during April 2011	Categorical	0=None 1=1 2=2 3=3 4=4 or more
Number of times received cell-level supervision visit in last month (*binômes* only)	Categorical	0=None 1=1-2 2=>2
Duration of last cell-level supervision visit (*binômes* only)	Categorical	0=No visit 1=<30 minutes 2=30-60 minutes 3=>60 minutes
Number of times received health center-level supervision visit in last quarter	Categorical	0=None 1=1-2 2=>2
Duration of last health center-level supervision visit	Categorical	0=No visit 1=<30 minutes 2=30-60 minutes

Variable	Type of variable	Description
		3=>60 minutes
CHW training (any; iCCM; monthly report) in the last six months	Categorical	0=No training 1=Any training
CHW training (any; iCCM; monthly report) ever	Categorical	0=No training 1=Any training
Household register only (except Kabarondo health center catchment area)		
CHW logged household visit for last month in List 9	Categorical	0=No 1=Yes
CHW keeps household register in wooden lockbox	Categorical	0=No 1=Yes
CHW keeps wooden box locked	Categorical	0=No 1=Yes

Table 22. Sociodemographic and CHW program variables for accuracy of household registers in southern Kayonza district

Variable	**Total (n=204)**
Mean age of CHW (95%CI)	37.4 (36.2, 38.8)
Median age of CHW (IQR)	36 (31, 43)
n	202
Sex (%)	
Male	110 (53.9%)
Female	94 (46.1%)
Civil status (%)	
Married/cohabiting	173 (84.8%)
Single	10 (4.9%)
Divorced/separated	5 (2.5%)
Widowed	16 (7.8%)
Mean number of living children (95%CI)	3.6 (3.4, 3.9)
Median number of living children (IQR)	4 (2, 5)
n	198
Education level (%)	
Incomplete primary	20 (9.8%)
Complete primary	148 (72.5%)
Incomplete secondary and higher	36 (17.6%)
Occupation (%)	
Farmer	200 (98.0%)
Other, none, missing	4 (2.0%)
Health center (%)	
Cyarubare	30 (14.7%)
Kabarondo	24 (11.8%)
Karama	30 (14.7%)
Ndego	24 (11.8%)
Nyamirama	24 (11.8%)
Ruramira	24 (11.8%)
Rutare	6 (2.9%)
Rwinkwavu	42 (20.6%)
Cooperative committee member (%)	
No	182 (89.7%)
Yes	21 (10.3%)
Mean number of years as CHW (95%CI)	3.7 (3.2, 4.2)
Median number of years as CHW (IQR)	4 (0, 5)
n	187
Mean number of households in CHW catchment area (95%CI)	56.2 (54.5, 57.9)
Median number of households in CHW catchment area (IQR)	54.5 (48, 63.5)
n	204
Mean walk to health center in minutes (95%CI)	92.3 (84.5, 100.1)
Median walk to health center in minutes (IQR)	90 (50, 120)
n	204
Visit from cell supervisor in last month (%)	
None	25 (12.3%)
1-2 times	176 (86.3%)
>2 times	2 (1.0%)
Missing	1 (0.5%)

Variable	Total (n=204)
Visit from health center supervisor in last quarter (%)	
None	17 (8.3%)
1-2 times	151 (74.0%)
>2 times	34 (16.7%)
Missing	2 (1.0%)
Duration of last visit from cell supervisor (%)	
No supervision visit	25 (12.3%)
<30 minutes	62 (30.4%)
30-60 minutes	101 (49.5%)
>60 minutes	15 (7.4%)
Missing	1 (0.5%)
Duration of last visit from health center supervisor (%)	
No supervision visit	17 (8.3%)
<30 minutes	49 (24.0%)
30-60 minutes	101 (49.5%)
>60 minutes	31 (15.2%)
Missing	6 (2.9%)
iCCM training in last 6 months (%)	
Yes	70 (34.3%)
No	134 (65.7%)
Monthly report training in last 6 months (%)	
Yes	1 (0.5%)
No	203 (99.5%)
Any training in last 6 months (%)	
Yes	197 (96.6%)
No	7 (3.4%)
iCCM training ever (%)	
Yes	191 (93.6%)
No	13 (6.4%)
Monthly report training ever (%)	
Yes	1 (0.5%)
No	203 (99.5%)
Any training ever (%)	
Yes	201 (98.5%)
No	3 (1.5%)
CHW kept HH register in wooden lock box (%) (except	
Yes	170 (94.4%)
No	34 (5.6%)
CHW kept wooden lock box locked (%) (except Kabarondo)	
Yes	110 (61.1%)
No	70 (38.9%)

Table 23. Crude and adjusted ORs and 95%CIs for accuracy (composite) of household registers in southern Kayonza district

Variable	OR	CRUDE 95% CI	P value*	OR	ADJUSTED** 95% CI	P Value*
Age of CHW	1.00	(0.989, 1.02)	0.595			
Sex						
Female vs. Male	1.180	(0.898, 1.54)	0.238			
Civil status						
Married/cohabiting (reference)	1.00					
Single	1.53	(0.740, 3.15)	0.252			
Divorced/separated	1.40	(0.501, 3.90)	0.521			
Widowed	1.37	(0.845, 2.22)	0.202			
Number of living children	1.00	(0.932, 1.07)	0.986			
Education level						
Incomplete primary (reference)	1.00					
Complete primary	0.767	(0.467, 1.26)	0.295			
Incomplete secondary and higher	0.960	(0.541, 1.70)	0.889			
Occupation						
Farmer (reference)	1.00					
Other, none, missing	0.967	(0.842, 1.11)	0.630			
Health center						
Ndego (reference)	1.00			1.00		
Cyarubare	1.06	(0.617, 1.83)	0.828	1.06	(0.616, 1.83)	0.828
Kabarondo	1.45	(0.865, 2.43)	0.158	2.30	(1.32, 3.99)	0.003
Karama	1.33	(0.811, 2.19)	0.257	1.50	(0.931, 2.41)	0.096
Nyamirama	1.13	(0.696, 1.83)	0.627	1.15	(0.722, 1.82)	0.563
Ruramira	1.61	(0.925, 2.79)	0.093	1.84	(1.07, 3.16)	0.028
Rutare	1.24	(0.527, 2.90)	0.626	1.16	(0.490, 2.76)	0.733
Rwinkwavu	1.45	(0.924, 2.28)	0.105	1.44	(0.920, 2.25)	0.111
Cooperative committee member						
Yes vs. No	0.820	(0.488, 1.38)	0.455			
Number of years as CHW	1.03	(0.984, 1.08)	0.210			
Number of households	0.999	(0.989, 1.01)	0.823			
Walk to health center in minutes	0.999	(0.996, 1.00)	0.354			
Visit from cell supervisor in last month						
None (reference)	1.00					
1-2 times	0.962	(0.629, 1.47)	0.856			
>2 times	1.41	(0.677, 2.94)	0.358			
Missing	2.35	(1.58, 3.51)	0.000			
Visit from health center supervisor in last quarter						
None (reference)	1.00					
1-2 times	1.29	(0.755, 2.22)	0.349			
>2 times	1.11	(0.612, 2.02)	0.727			
Missing	0.831	(0.412, 1.68)	0.606			
Duration of last cell supervisor visit						
No supervision visit (reference)	1.00					
<30 minutes	0.919	(0.580, 1.45)	0.718			
30-60 minutes	0.970	(0.621, 1.51)	0.892			
>60 minutes	1.16	(0.607, 2.21)	0.656			

Variable	OR	CRUDE 95% CI	P value*	OR	ADJUSTED** 95% CI	P Value*
Missing	2.35	(1.58, 3.51)	0.000			
Duration of last health center supervisor visit						
No supervision visit (reference)	1.00					
<30 minutes	1.12	(0.623, 2.00)	0.709			
30-60 minutes	1.36	(0.787, 2.36)	0.270			
>60 minutes	1.19	(0.631, 2.24)	0.595			
Missing	1.05	(0.601, 1.84)	0.863			
iCCM training in last 6 months						
Yes vs. No	0.966	(0.732, 1.28)	0.808			
Monthly report training in last 6 months						
Yes vs. No	0.967	(0.844, 1.11)	0.630			
Any training in last 6 months						
Yes vs. No	1.42	(0.765, 2.65)	0.264			
iCCM training ever						
Yes vs. No	1.04	(0.585, 1.84)	0.903			
Monthly report training ever						
Yes vs. No	2.43	(2.12, 2.78)	0.000	4.89	(3.28, 7.30)	0.000
Any training ever						
Yes vs. No	1.32	(0.886, 1.97)	0.171			
CHW logged visit to household in last month in HH register						
No (reference)	1.00			1.00		
Yes	1.54	(1.11, 2.15)	0.010	1.71	(1.22, 2.39)	0.002
Missing (Kabarondo)	1.62	(1.01, 2.59)	0.046	-	-	-
CHW stored HH register in wooden box	0.865	(0.498, 1.50)	0.606			
Yes vs. No	1080					
CHW locked wooden box						
Yes vs. No	1.12	(0.842, 1.49)	0.431			

*Wald test
**All variables with P value < 0.1 in crude models

Table 24. Sociodemographic and CHW program variables by district

	District				
	Southern Kayonza (n=471)	**Northern Kayonza (n=180)**	**Kirehe (n=526)**	**Total (n=1177)**	**P value***
Sociodemographic variables					
Mean age of CHW (95%CI)	38.2 (37.0, 39.4)	39.8 (37.9, 41.8)	38.4 (37.2, 39.5)	38.5 (37.8, 39.3)	0.077
Median age of CHW (IQR)	37 (31.5, 43)	40 (34, 44)	37 (32, 44)	37 (32, 43.5)	
n	468	177	519	1164	
Sex (%)					0.685
Male	223 (47.3%)	86 (47.8%)	263 (50.0%)	572 (48.6%)	
Female	248 (52.7%)	94 (52.2%)	263 (50.0%)	605 (51.4%)	
Civil status (%)					0.007
Married/cohabiting	404 (85.8%)	160 (88.9%)	490 (93.2%)	1054 (89.5%)	
Single	27 (5.7%)	6 (3.3%)	12 (2.3%)	45 (3.8%)	
Divorced/separated	12 (2.5%)	2 (1.1%)	4 (0.8%)	18 (1.5%)	
Widowed	27 (5.7%)	12 (6.7%)	20 (3.8%)	59 (5.0%)	
Mean number of living children (95%CI)	3.8 (3.7, 3.9)	3.9 (3.7, 4.2)	3.9 (3.7, 4.2)	3.9 (3.8, 4.0)	0.340
Median number of living children (IQR)	4 (2, 5)	4 (3, 5)	4 (3, 5)	4 (3, 5)	
n	456	168	519	1143	
Education level (%)					0.378
Incomplete primary	41 (8.7%)	14 (7.8%)	55 (10.5%)	110 (9.3%)	
Complete primary	339 (72.0%)	119 (66.1%)	359 (68.3%)	817 (69.4%)	
Incomplete secondary +	91 (19.3%)	45 (25.0%)	110 (20.9%)	246 (20.9%)	
Occupation (%)					0.000
Farmer	461 (97.9%)	165 (91.7%)	516 (98.1%)	1142 (97.0%)	
Other, none, missing	10 (2.1%)	15 (8.3%)	10 (1.9%)	35 (3.0%)	
CHW program variables					
Cooperative committee member (%)					0.000
Yes	50 (10.6%)	33 (18.3%)	39 (7.4%)	122 (10.4%)	
No	420 (89.2%)	147 (81.7%)	486 (92.4%)	1053 (89.5%)	
CHW type (%)					0.083
Cell coordinator	12 (2.5%)	8 (4.4%)	28 (5.3%)	48 (4.1%)	
Binôme only	459 (97.5%)	171 (95.0%)	498 (94.7%)	1128 (95.8%)	

	District				
	Southern Kayonza (n=471)	Northern Kayonza (n=180)	Kirehe (n=526)	Total (n=1177)	P value*
Mean number of years as CHW (95%CI)	4.1 (3.5, 4.7)	5.4 (4.1, 6.6)	5.8 (5.4, 6.1)	5.0 (4.5, 5.5)	0.000
Median number of years as CHW (IQR)	4 (1, 5)	4 (3, 7)	6 (4, 7)	5 (3, 6)	
n	471	179	523	1173	
Mean number of households in CHW catchment area (95%CI)	56.3 (52.3, 60.4)	77.4 (69.0, 85.7)	36.7 (30.3, 43.0)	50.7 (44.1, 57.3)	0.000
Median number of households in CHW catchment area (IQR)	54 (48, 63)	75 (59, 93)	31 (24, 42)	49 (32, 62)	
n	454	179	522	1155	
Mean walk to health center in minutes (95%CI)	90.0 (72.2, 107.7)	163.1 (122.7, 203.4)	95.9 (82.6, 109.2)	103.8 (89.0, 118.6)	0.000
Median walk to health center in minutes (IQR)	90 (50, 120)	150 (90, 240)	90 (60, 120)	90 (60, 150)	
n	470	180	526	1176	
Mean number of sick children seen (as reported in iCCM register in April 2011) (95%CI)	2.3 (1.6, 3.0)	3.5 (1.9. 5.1)	1.6 (1.3, 1.9)	2.2 (1.7, 2.6)	0.000
Median number of sick children seen (as reported in iCCM register in April 2011) (IQR)	2 (0, 3)	2 (1, 5)	1 (0, 3)	1 (0, 3)	
n	471	175	526	1172	
Visit from cell supervisor in last month (%)					0.000
None	59 (12.9%)	70 (40.7%)	101 (20.3%)	230 (20.4%)	
1-2 times	393 (85.6%)	102 (59.3%)	405 (81.3%)	900 (79.7%)	
>2 times	4 (0.9%)	0 (0.0%)	7 (1.4%)	11 (1.0%)	
Missing	3 (0.7%)	1 (0.6%)	3 (0.6%)	7 (0.6%)	
Visit from health center supervisor in last quarter (%)					0.000
None	43 (9.1%)	29 (16.1%)	93 (17.7%)	165 (14.0%)	
1-2 times	319 (67.7%)	139 (77.2%)	340 (64.6%)	798 (67.8%)	
>2 times	95 (20.2%)	12 (6.7%)	85 (16.2%)	192 (16.3%)	
Missing	11 (2.3%)	0 (0.0%)	8 (1.5%)	19 (1.6%)	
Duration of last visit from cell supervisor (%)					0.000
No supervision visit	59 (12.9%)	70 (40.7%)	100 (20.1%)	229 (20.3%)	
<30 minutes	126 (27.5%)	45 (26.2%)	110 (22.1%)	281 (24.9%)	
30-60 minutes	226 (49.2%)	36 (20.9%)	232 (46.6%)	494 (43.8%)	
>60 minutes	45 (9.8%)	19 (11.0%)	53 (10.6%)	117 (10.4%)	

	District				
	Southern Kayonza (n=471)	Northern Kayonza (n=180)	Kirehe (n=526)	Total (n=1177)	P value*
Missing	3 (0.7%)	2 (1.2%)	3 (0.6%)	8 (0.7%)	
Duration of last visit from health center supervisor (%)					0.000
No supervision visit	43 (9.1%)	29 (16.1%)	93 (17.7%)	165 (14.0%)	
<30 minutes	110 (23.4%)	61 (33.9%)	94 (17.9%)	265 (22.5%)	
30-60 minutes	227 (48.2%)	52 (28.9%)	234 (44.5%)	513 (43.6%)	
>60 minutes	74 (15.7%)	37 (20.6%)	96 (18.3%)	207 (17.6%)	
Missing	17 (3.6%)	1 (0.6%)	9 (1.7%)	27 (2.3%)	
iCCM training in last six months (%)					0.000
Yes	181 (38.4%)	0 (0.0%)	25 (4.8%)	206 (17.5%)	
No	290 (61.6%)	180 (100.0%)	501 (95.2%)	971 (82.5%)	
Monthly report training in last six months (%)					0.032
Yes	4 (0.8%)	0 (0.0%)	14 (2.7%)	18 (1.5%)	
No	467 (99.2%)	180 (100.0%)	512 (97.3%)	1159 (98.5%)	
Any training in last six months (%)					0.138
Yes	460 (97.7%)	174 (96.7%)	520 (98.9%)	1154 (98.0%)	
No	11 (2.3%)	6 (3.3%)	6 (1.1%)	23 (2.0%)	
iCCM training ever (%)					0.205
Yes	451 (95.8%)	173 (96.1%)	512 (97.3%)	1136 (96.5%)	
No	20 (4.2%)	7 (3.9%)	12 (2.3%)	39 (3.3%)	
Monthly report training ever (%)					0.000
Yes	4 (0.8%)	88 (48.9%)	399 (75.9%)	491 (41.7%)	
No	467 (99.2%)	92 (51.1%)	125 (23.8%)	684 (58.1%)	
Any training ever (%)					0.415
Yes	466 (98.9%)	179 (99.4%)	524 (99.6%)	1169 (99.3%)	
No	5 (1.1%)	1 (0.6%)	2 (0.4%)	8 (0.7%)	

*Pearson's $\chi 2$ test for categorical variables and F-test adjusting SE for clustering by health center with continuous variables

Table 25. Crude and adjusted Odds Ratios (ORs) and 95% confidence intervals (95%CIs) of predictors for reliability of village monthly reports (composite) across all districts

	CRUDE			ADJUSTED**		
Variable	**OR**	**95% CI**	**P value***	**OR**	**95% CI**	**P Value***
Age of CHW	1.00	(0.989, 1.02)	0.641			
Sex						
Female vs. Male	0.930	(0.847, 1.02)	0.125			
Civil status						
Married/cohabiting (reference)	1.00					
Single	1.32	(0.837, 2.07)	0.235			
Divorced/separated	1.20	(0.592, 2.44)	0.609			
Widowed	1.11	(0.650, 1.88)	0.712			
Number of living children	1.01	(0.947, 1.08)	0.707			
Education level						
Incomplete primary (reference)	1.00					
Complete primary	0.837	(0.548, 1.28)	0.410			
Incomplete secondary and higher	1.10	(0.697, 1.74)	0.677			
Occupation						
Farmer (reference)	1.00					
Other, none, missing	0.870	(0.424, 1.79)	0.704			
District						
Southern Kayonza (reference)	1.00			1.00		
Northern Kayonza	1.72	(0.854, 3.46)	0.129	2.55	(1.33, 4.88)	0.005
Kirehe	5.67	(3.31, 9.73)	0.000	6.30	(3.42, 11.6)	0.000
Cooperative committee member						
Yes vs. No	0.919	(0.558, 1.51)	0.739			
CHW type						
Cell coordinator v. *binôme* only	1.06	(0.617, 1.81)	0.841			
Number of years as CHW (spline)						
0-5 years (linear spline)	1.19	(1.08, 1.32)	0.000	1.06	(0.971, 1.15)	0.204
>5 years (linear spline)	0.806	(0.697, 0.931)	0.003	0.940	(0.827, 1.07)	0.349
Number of households in CHW catchment area (categorical)						
0-35 households (reference)	1.00			1.00		
36-60 households	0.299	(0.171, 0.523)	0.000	0.961	(0.651, 1.42)	0.843
>60 households	0.372	(0.225, 0.615)	0.000	1.36	(0.739 2.48)	0.326
Walk to health center in minutes	0.997	(0.993, 1.00)	0.073	0.997	(0.994, 0.999)	0.015
Number of sick children seen recorded in register during April 2011 (categorical)						
None	1.00			1.00		
1	0.666	(0.497, 0.893)	0.007	0.609	(0.423, 0.877)	0.008
2	0.518	(0.318, 0.845)	0.008	0.478	(0.262, 0.869)	0.015
3	0.447	(0.285, 0.702)	0.000	0.371	(0.230, 0.596)	0.000
4 or more	0.259	(0.178, 0.379)	0.000	0.283	(0.180, 0.445)	0.000
Visit from cell supervisor in last month (*binômes* only)						
None (reference)	1.00					
1-2 times	1.05	(0.636, 1.72)	0.861			

Variable	CRUDE OR	95% CI	P value*	ADJUSTED** OR	95% CI	P Value*
>2 times	1.85	(0.610, 5.63)	0.277			
Missing	1.16	(0.175, 7.67)	0.879			
Visit from health center supervisor in last quarter						
None (reference)	1.00					
1-2 times	0.899	(0.510, 1.59)	0.714			
>2 times	0.849	(0.358, 2.01)	0.710			
Missing	0.473	(0.110, 2.03)	0.313			
Duration of last cell supervisor visit (*binôme*s only)						
No supervision visit (reference)	1.00					
<30 minutes	1.01	(0.563, 1.81)	0.977			
30-60 minutes	1.09	(0.649, 1.82)	0.753			
>60 minutes	1.00	(0.535, 1.87)	0.998			
Missing	1.54	(0.258, 9.26)	0.634			
Duration of last health center supervisor visit						
No supervision visit (reference)	1.00			1.00		
<30 minutes	0.658	(0.338, 1.28)	0.219	0.865	(0.458, 1.63)	0.655
30-60 minutes	1.12	(0.602, 2.08)	0.722	1.45	(0.959, 2.18)	0.079
>60 minutes	0.768	(0.367, 1.61)	0.484	0.892	(0.474, 1.68)	0.722
Missing	0.301	(0.0830, 1.09)	0.068	0.424	(0.146, 1.23)	0.114
iCCM training in last six months						
Yes vs. No	0.535	(0.333, 0.860)	0.010	1.14	(0.755, 1.73)	0.530
Monthly report training in last six months						
Yes vs. No	1.87	(0.708, 4.92)	0.207			
Any training in last six months						
Yes vs. No	1.05	(0.392, 2.83)	0.918			
iCCM training ever						
Yes vs. No	1.37	(0.643, 2.90)	0.417			
Monthly report training ever						
Yes vs. No	3.10	(1.84, 5.24)	0.000			
Any training ever						
Yes vs. No	1.13	(0.461, 4.76)	0.791			

*Wald test
**All variables with P value < 0.1 in crude models (except “Monthly report training ever” as collinear with “District”)

Table 26. Crude and adjusted ORs and 95%CIs of predictors for reliability of village monthly reports (composite) for southern Kayonza district

	CRUDE			ADJUSTED**		
Variable	**OR**	**95% CI**	**P value***	**OR**	**95% CI**	**P value***
Age of CHW	1.02	(0.992, 1.05)	0.167			
Sex						
Female vs. Male	0.874	(0.710, 1.07)	0.202			
Civil status						
Married/cohabiting (reference)	1.00					
Single	1.63	(0.670, 3.96)	0.282			
Divorced/separated	1.93	(0.659, 6.68)	0.230			
Widowed	0.879	(0.437, 1.77)	0.717			
Number of living children	1.07	(0.886, 1.29)	0.488			
Education level						
Incomplete primary (reference)	1.00					
Complete primary	1.02	(0.358, 2.88)	0.976			
Incomplete secondary and higher	1.56	(0.659, 3.71)	0.311			
Occupation						
Farmer (reference)	1.00					
Other, none, missing	2.53	(0.718, 8.95)	0.149			
Cooperative committee member						
Yes vs. No	1.51	(0.808, 2.82)	0.196			
CHW type						
Cell coordinator v. *binôme* only	1.89	(0.885, 4.04)	0.100			
Number of years as CHW	1.06	(1.02, 1.11)	0.002	1.08	(1.02, 1.14)	0.005
Number of years as CHW (spline)						
0-5 years (linear spline)	1.08	(0.987, 1.19)	0.093			
>5 years (linear spline)	0.966	(0.802, 1.16)	0.719			
Number of households in CHW catchment area	1.03	(1.00, 1.05)	0.027	1.02	(0.994, 1.05)	0.122
Number of households in CHW catchment area (categorical)						
0-35 households (reference)	1.00					
36-60 households	0.408	(0.083, 2.01)	0.270			
>60 households	0.784	(0.181, 3.39)	0.744			
Walk to health center in minutes	0.995	(0.989, 1.00)	0.056	0.998	(0.993, 1.00)	0.396
Number of sick children seen recorded in register during April 2011	0.803	(0.625, 1.03)	0.084			
Number of sick children seen recorded in register during April 2011 (categorical)						
None	1.00			1.00		
1	0.782	(0.364, 1.67)	0.526	0.805	(0.364, 1.779)	0.592
2	0.625	(0.228, 1.72)	0.362	0.675	(0.218, 2.09)	0.497
3	0.425	(0.191, 0.945)	0.036	0.317	(0.130, 0.773)	0.011
4 or more	0.188	(0.069, 0.510)	0.001	0.206	(0.083, 0.510)	0.001

	CRUDE			ADJUSTED**		
Variable	**OR**	**95% CI**	**P value***	**OR**	**95% CI**	**P value***
Visit from cell supervisor in last month (for *binômes* only)						
None (reference)	1.00					
1-2 times	1.81	(0.934, 3.52)	0.079			
>2 times	-					
Missing	3.19	(0.115, 88.1)	0.494			
Visit from health center supervisor in last quarter						
None (reference)	1.00					
1-2 times	2.04	(0.636, 6.53)	0.230			
>2 times	1.07	(0.328, 3.47)	0.916			
Missing	-					
Duration of last cell supervisor visit (for *binômes* only)						
No supervision visit (reference)	1.00			1.00		
<30 minutes	1.66	(0.767, 3.58)	0.199	2.18	(0.715, 6.65)	0.171
30-60 minutes	1.95	(0.908, 4.20)	0.087	1.70	(0.645, 4.47)	0.284
>60 minutes	1.38	(0.693, 2.74)	0.361	1.33	(0.439, 4.05)	0.612
Missing	3.19	(0.115, 88.1)	0.494	16.1	(0.122, 2120)	0.264
Duration of last health center supervisor visit						
No supervision visit (reference)	1.00			1.00		
<30 minutes	0.725	(0.267, 1.97)	0.581	0.589	(0.144, 2.42)	0.463
30-60 minutes	3.03	(1.08, 8.53)	0.035	2.39	(0.847, 6.75)	0.100
>60 minutes	2.56	(0.566, 11.5)	0.222	2.30	(0.478, 11.1)	0.298
iCCM training in last six months						
Yes vs. No	0.977	(0.719, 1.33)	0.883			
Monthly report training in last six months						
Yes vs. No	NA					
Any training in last six months						
Yes vs. No	1.22	(0.304, 4.88)	0.780			
iCCM training ever						
Yes vs. No	0.614	(0.286, 1.32)	0.212			
Monthly report training ever						
Yes vs. No	NA					
Any training ever						
Yes vs. No	0.399	(0.242, 0.658)	0.000	0.192	(0.107, 0.345)	0.000

*Wald test
**All variables with P value < 0.1 in crude models

Table 27. Crude and adjusted ORs and 95%CIs of predictors for reliability of village monthly reports (composite) in northern Kayonza district

	CRUDE		
Variable	**OR**	**95% CI**	**P value***
Age of CHW	0.981	(0.946, 1.02)	0.290
Sex			
Female vs. Male	1.02	(0.780, 1.35)	0.863
Civil status			
Married/cohabiting (reference)	1.00		
Single	1.13	(0.451, 2.85)	0.791
Divorced/separated	2.27	(1.26, 4.08)	0.006
Widowed	1.62	(0.594, 4.41)	0.347
Number of living children	0.928	(0.711, 1.21)	0.584
Education level			
Incomplete primary (reference)	1.00		
Complete primary	1.13	(0.558, 2.28)	0.737
Incomplete secondary and higher	1.25	(0.379, 4.13)	0.714
Occupation			
Farmer (reference)	1.00		
Other, none, missing	0.514	(0.119, 2.22)	0.373
Cooperative committee member			
Yes vs. No	0.773	(0.214, 2.79)	0.695
CHW type			
Cell coordinator v. *binôme* only	0.703	(0.269, 1.83)	0.472
Number of years as CHW	0.975	(0.892, 1.07)	0.580
Number of years as CHW			
0-5 years (linear spline)	1.01	(0.759, 1.34)	0.946
>5 years (linear spline)	0.945	(0.663, 1.35)	0.652
Number of households in CHW catchment area	1.01	(0.994, 1.03)	0.219
Number of households in CHW catchment area (categorical)			
0-35 households (reference)	1.00		
36-60 households	0.417	(0.173, 1.00)	0.051
>60 households	1.81	(0.518, 6.36)	0.352
Walk to health center in minutes	0.999	(0.993, 1.00)	0.643
Number of sick children seen recorded in register during April 2011	0.947	(0.836, 1.07)	0.395
Number of sick children seen recorded in register during April 2011 (categorical)			
None (reference)	1.00		
1	0.333	(0.148, 0.750)	0.008
2	0.535	(0.120, 2.37)	0.410
3	1.00	(0.276, 3.62)	1.00
4 or more	0.407	(0.173, 0.959)	0.040
Visit from cell supervisor in last month			
None (reference)	1.00		
1-2 times	0.547	(0.201, 1.49)	0.239

		CRUDE	
Variable	**OR**	**95% CI**	**P value***
>2 times	-		
Missing	-	(0.025, 1.85)	0.161
Visit from health center supervisor in last quarter			
None (reference)	1.00		
1-2 times	0.88	(0.0974, 7.95)	0.909
>2 times	0.633	(0.0194, 20.7)	0.797
Missing	-		
Duration of last cell supervisor visit			
No supervision visit (reference)	1.00		
<30 minutes	0.429	(0.0918, 2.00)	0.281
30-60 minutes	0.500	(0.152, 1.65)	0.254
>60 minutes	0.875	(0.536, 1.43)	0.594
Missing	1.50	(0.0691, 32.6)	0.796
Duration of last health center supervisor visit			
No supervision visit (reference)	1.00		
<30 minutes	1.17	(0.0764, 17.8)	0.911
30-60 minutes	0.730	(0.0917, 5.81)	0.766
>60 minutes	0.480	(0.0384, 6.00)	0.569
iCCM training in last 6 months			
Yes vs. No	-		
Monthly report training in last 6 months			
Yes vs. No	-		
Any training in last 6 months			
Yes vs. No	0.924	(0.129, 6.64)	0.938
iCCM training ever			
Yes vs. No	-		
Monthly report training ever			
Yes vs. No	1.12	(0.370, 3.41)	0.837
Any training ever			
Yes vs. No	-		

*Wald test
**All variables with P value < 0.1 in crude models

Table 28. Crude and adjusted ORs and 95%CIs of predictors for reliability of village monthly reports (composite) in Kirehe district

Variable	CRUDE			ADJUSTED**		
	OR	95% CI	P value*	OR	95% CI	P Value*
Age of CHW	1.00	(0.985, 1.02)	0.825			
Sex						
Female vs. Male	1.00	-	-			
Civil status						
Married/cohabiting (reference)	1.00			1.00		
Single	7.65	(1.27, 46.1)	0.026	8.73	(1.52, 50.4)	0.015
Divorced/separated	2.09	(0.395, 11.0)	0.386	1.52	(0.174, 13.3)	0.704
Widowed	2.09	(0.807, 5.40)	0.129	2.22	(0.766, 6.41)	0.142
Number of living children	0.974	(0.915, 1.04)	0.402			
Education level						
Incomplete primary (reference)	1.00					
Complete primary	0.805	(0.385, 1.68)	0.565			
Incomplete secondary and higher	1.04	(0.457, 2.37)	0.925			
Occupation						
Farmer (reference)	1.00					
Other, none, missing	0.981	(0.402, 2.40)	0.966			
Cooperative committee member						
Yes vs. No	1.05	(0.475, 2.34)	0.897			
CHW type						
Cell coordinator v. *binôme* only	0.638	(0.312, 1.30)	0.218			
Number of years as CHW	0.993	(0.949, 1.04)	0.753			
Number of years as CHW (spline)						
0-5 years (linear spline)	0.989	(0.889, 1.10)	0.844			
>5 years (linear spline)	1.010	(0.843, 1.20)	0.947			
Number of households in CHW catchment area	0.995	(0.989, 1.00)	0.092	0.994	(0.988, 1.00)	0.073
Number of households in CHW catchment area (categorical)						
0-35 households (reference)	1.00					
36-60 households	1.15	(0.782, 1.70)	0.473			
>60 households	0.622	(0.276, 1.40)	0.251			
Walk to health center in minutes	0.996	(0.991, 1.00)	0.031	0.994	(0.990, 0.998)	0.009
Number of sick children seen recorded in register during April 2011	0.817	(0.726, 0.920)	0.001			
Number of sick children seen recorded in register during April 2011 (categorical)						
None (reference)	1.00			1.00		
1	0.617	(0.382, 1.00)	0.049	0.532	(0.322, 0.880)	0.014
2	0.439	(0.198, 0.974)	0.043	0.415	(0.190, 0.904)	0.027
3	0.363	(0.191, 0.691)	0.002	0.330	(0.176, 0.617)	0.001
4 or more	0.336	(0.190, 0.593)	0.000	0.280	(0.145, 0.541)	0.000
Visit from cell supervisor in last month						
None (reference)	1.00					
1-2 times	1.41	(0.784, 2.54)	0.250			

Variable	CRUDE			ADJUSTED**		
	OR	95% CI	P value*	OR	95% CI	P Value*
>2 times	5.11	(1.04, 25.2)	0.045			
Missing	1.70	(0.101, 28.8)	0.712			
Visit from health center supervisor in last quarter						
None (reference)	1.00					
1-2 times	0.987	(0.735, 1.33)	0.931			
>2 times	1.48	(0.817, 2.70)	0.195			
Missing	1.15	(0.179, 7.39)	0.882			
Duration of last cell supervisor visit						
No supervision visit (reference)	1.00			1.00		
<30 minutes	1.83	(0.891, 3.74)	0.100	1.79	(0.766, 4.19)	0.178
30-60 minutes	1.34	(0.761, 2.37)	0.309	1.44	(0.717, 2.90)	0.305
>60 minutes	1.2	(0.526, 2.74)	0.664	1.42	(0.630, 3.20)	0.398
Missing	1.7	(1.01, 28.8)	0.712	1.44	(0.091, 22.8)	0.794
Duration of last health center supervisor visit						
No supervision visit (reference)	1.00					
<30 minutes	1.06	(0.593, 1.89)	0.848			
30-60 minutes	1.35	(0.907, 2.02)	0.237			
>60 minutes	0.742	(0.441, 1.25)	0.261			
Missing	0.889	(0.269, 2.94)	0.848			
iCCM training in last six months						
Yes vs. No	3.61	(1.42, 9.16)	0.007	4.57	(1.55, 13.5)	0.006
Monthly report training in last six months						
Yes vs. No	1.66	(1.17, 2.34)	0.004	0.712	(0.419, 1.21)	0.210
Any training in last six months						
Yes vs. No	0.302	(0.0242, 3.77)	0.353			
iCCM training ever						
Yes vs. No	1.10	(0.321, 3.75)	0.884			
Monthly report training ever						
Yes vs. No	1.22	(0.627, 2.38)	0.555			
Any training ever						
Yes vs. No	1.53	(0.0984, 23.8)	0.761			

*Wald test

**All variables with P value < 0.1 in crude models

Chapter 7. Conclusions

This dissertation looked at baseline measurements of accuracy and reliability of CHW data, and factors related to them across three districts in Eastern Province, Rwanda. A summary of results for each manuscript is presented below, followed by strengths, limitations and generalizability of the study and recommendations for future research.

7.1 Summary of results

Manuscript 1

A total of 34 cells, 204 CHWs and their household registers for 1,224 households were included in this study across eight health center catchment areas in southern Kayonza district.

Data accuracy varied considerably between indicators ranging from 23 of 34 cells classified as 'good' for *number of children under 5*, 19 of 34 for *number of women on modern family planning method*, 18 of 34 for *number of women 15-49 years*, and 14 of 34 for *type of family planning method*. *Number of home deliveries* in all but a few cases was a zero value and therefore made it difficult to assess accuracy (34 of 34 cells had 'good' classifications). While no cell had concordant household register entries and visit information across all indicators (composite), three had 'good' classifications for all individual indicators.

Point estimates of household data across health centers for individual indicators ranged from 79% to 100%, while the composite indicator ranged from 61% to 72%. While *number of home deliveries* was the most accurate, all other individual indicator point estimates were not statistically significantly different from each other.

For four of the indicators, the data recording error seemed random. The indicator *number of women on modern family planning* was under-reported for 88% of households mis-reported (95%CI: 86%, 90%) by a median of one (IQR: -1, -1).

Manuscript 2

We compared three iCCM program indicators from 501 April 2011 monthly village reports with iCCM registers tallies for 1,102 CHWs. We assessed and classified data reliability from 27 health center catchment areas. We then calculated point estimates for three districts with varying partner support and CHW experience with the iCCM program.

In southern and northern Kayonza districts, one out of eight and one out of six health center catchment areas respectively had 'good' data quality for the indicators *total sick children* seen and *children treated for pneumonia and recovered*. In Kirehe, nine and 13 of 13 health center catchment areas had 'good' classifications for the same indicators, respectively. The indicator *children treated for fever and referred to health center* had the lowest point estimates in southern Kayonza (58%; 95%CI: 52%, 63%) and Kirehe (72%; 95%CI: 68%, 77%) districts. Conversely, in northern Kayonza, it had the highest point estimate at 89% (95%CI: NA), though this was likely due to the high number of zero entries in the reports and registers. Additionally, when the indicator was misreported, it was over-reported by a median of 2 (IQR: 1,3) in northern Kayonza and Kirehe and 3 (IQR: 1,4) in southern Kayonza. Otherwise, reporting error was largely random.

Overall, point estimates for the composite indicator ('good' only if all three indicators were concordant) were much lower at 26% (95%CI: 21%, 32%) for southern Kayonza; 32% (95%CI: 26%, 38%) in northern Kayonza; and 60% (95CI: 55%, 65%) in Kirehe, with no health center catchment area being classified as having 'good' data quality in northern and southern Kayonza, and only two in Kirehe.

Manuscript 3

We included a total of 204 CHWs and 1,224 households in the analysis of data accuracy (100% of those eligible). We included a total of 471 CHWs in southern Kayonza, 180 CHWs in northern Kayonza and 526 CHWs in Kirehe (n=1,177) in the final analysis of data reliability (98% of those eligible).

In the accuracy study, for 204 CHWs, 825 household entries had 'good' accuracy and 399 had 'poor' accuracy. Overall, 475 CHWs had 'good' data reliability and 702 had 'poor' data reliability defined by the composite indicator.

Factors related to data accuracy

There was little variation in sociodemographic characteristics among CHWs in the accuracy study in southern Kayonza. The median age was 36 years, with a little over half being male. Most CHWs were married or cohabiting (84.8%) with a median of four living children. Almost three quarters had completed primary education, and almost all reported farming as their primary occupation. Roughly 10% were members of the cooperative committee and had been CHWs for a median of four years. CHWs had an average of 56 households in their catchment areas with a mean walk of just over 1.5 hours to their health center. Roughly three quarters received at least one visit from the health center in the last quarter, and just under 90% received a visit from their cell supervisor in the last month. The duration of these visits varied, with about half of CHWs receiving visits 30-60 minutes long. Roughly one third of CHWs had received iCCM training in the last six months, and almost all of them had ever received it. Conversely, only one CHW had ever received a monthly report training (this may be a reporting error given that CHWs generally receive training at the same time by health center). While almost all of the CHWs kept their household register in the wooden lock box they received as part of the national program, only 61.1% kept the box locked. Finally, all but two of the health centers had four or five cell supervision catchment areas: Rutare only had one, and Rwinkwavu had seven.

Aside from health center, after adjusting for all other predictors in the model, CHW having logged a visit to the household in the last month in the household register increased odds of accurate data 1.71 times (95%CI: 1.22, 2.39) in the adjusted model. Ever having received monthly report training was positively associated with data accuracy (OR: 4.89; 95%CI: 3.28, 7.30) though the sub-sample of CHWs who did receive the training was very small (n=1).

Factors related to data reliability

Sociodemographic variables were similar among CHWs across the three districts as in southern Kayonza. The mean number of years as a CHW was five with variation by district (4.1 in southern Kayonza to 5.8 in Kirehe). CHWs were responsible for an average of 50.7 households, but again, this ranged from a low of 36.7 in Kirehe to a high of 77.4 in northern Kayonza. Similarly, while the mean walk in minutes to a health center was 103.8, CHWs in northern Kayonza lived much farther away (163.1 minutes) than those in either of the other two districts. Correspondingly, CHWs saw on average more sick children in April 2011 (3.5) than in southern Kayonza (2.3) or Kirehe (1.6). The majority of CHWs received at least one cell supervision visit in the last month (79.7%) and at least one health center supervision visit in the last quarter (67.8%). However, 20.4% did not receive any cell supervision visits and 14% did not receive and health center supervision visits.

In terms of training, the majority of CHWs (82.5%) received iCCM training in the last six months, and almost all (96.5%) had ever received it. In contrast, fewer than half (41.7%) of CHWs had received any monthly report training ever and in southern Kayonza, nearly none had. Overall, almost all CHWs had received any training in the last six months.

All districts

Number of sick children seen in April 2011 was the strongest predictor of reliability, controlling for all other predictors. The more sick children recorded being seen in April 2011 in the consultation registers by CHWs, the worse the data reliability. Compared with seeing no sick children, with one sick child, holding all other variables constant, CHWs were more than a third less likely to have reliable data (OR: 0.609; 95%CI: 0.423, 0.877). With four or more sick children, they were more than two thirds less likely (OR: 0.283; 95%CI: 0.180, 0.445) to have reliable data. Additionally, the farther the walk from a health center, the worse the data reliability (OR: 0.997; 95%CI: 0.994, 0.999) – for every minute away from the health center, the odds that data were reliable decreased by 0.3%.

Southern Kayonza

Results were similar when analyzing the reliability dependent variable by district. Holding the other predictors in the model constant, the more time spent as a CHW, the better the data reliability (OR: 1.08; 95%CI: 1.02, 1.14); the more sick children seen in April 2011, the worse the data reliability – though the associations were only significant for three (OR: 0.317; 95%CI: 0.130, 0.773) and four or more children (OR: 0.206; 95%CI: 0.083, 0.510) as compared to no children. Finally, the any training received variable remained significant when adjusting for other predictors, though the number of CHWs never receiving training was only five out of 471 (OR: 0.192; 95%CI: 0.107, 0.345).

Northern Kayonza

In northern Kayonza, the adjusted model fit poorly and therefore, we only present results for the crude model. This included CHWs whose civil status was divorced/separated were more than two times likely than their married/cohabiting counterparts to have good data reliability (OR: 2.27; 95%CI: 1.26, 4.08). Number of sick children seen in April 2011 was also significant for one versus none (OR: 0.333; 95%CI: 0.148, 0.750) and four or more versus none (OR: 0.407; 95%CI: 0.173, 0.959). Finally, the number of households (categorical variable) was significantly associated with poorer data reliability at 36-60 households (OR: 0.417; 95%CI: 0.173, 1.00) versus <36 households.

Kirehe

Civil status was the only statistically significant CHW characteristic in both the crude and adjusted models. Controlling for other predictors, single CHWs were more than eight times more likely to have good data reliability than married/cohabiting CHWs, though the confidence interval is very wide due to the small number of unmarried CHWs (OR: 8.73; 95%CI: 1.53, 50.4). Other significantly associated program-related factors were similar to the all-district model: time to health center was inversely associated with data reliability so that adjusting for all other predictors, the odds of the data being reliable decreased for every minute farther the CHW has to walk to the health center (OR: 0.994; 95%CI: 0.990, 0.998); the greater the number of sick children seen in April 2011, the worse the data reliability. Holding all other predictors constant, the odds of good data reliability are reduced by about half with one sick child compared with none (OR: 0.532; 95%CI: 0.322, 0.880); 60% with two sick children (OR: 0.415; 95%CI: 0.190, 0.904);

67% with three sick children (OR: 0.330; 95%CI: 0.176, 0.617); and 72% with four or more children (OR: 0.280; 95%CI: 0.145, 0.541).

Main conclusions

Governments and other organizations utilize CHW-generated data extensively for program management, evaluation and quality assurance; therefore, it is critical that these stakeholders are confident that the data are of sufficient quality to warrant their use.

Our results show that data accuracy of CHW household registers was overall 'good' across cell catchment areas in one district. Conversely, our results also demonstrated that data reliability of CHW monthly village reports in Rwanda, was overall 'poor' across health center catchment areas in three districts. This indicates that CHWs are able to collect household-level information correctly, but are not as skilled at aggregating it.

Additionally, misreporting of the selected indicators in this study appear to not have been purposeful or ill-motivated. While not ideal, the randomness of errors in reporting may allay potential fear that CHWs may be over-reporting certain indicators for which they receive compensation through the PBF system (though over-treating may still be an issue).

Informal observations and CHW interviews conducted during these data quality assessments suggest that poor data quality could be due to: 1) program monitoring system-related factors including design and supply of forms, registers and reports, indicator definitions, reporting procedures, training materials and content, quality of supervision; and 2) CHW-related factors including numeracy, literacy, experience, CHW to population ratio, and client volume. Our analysis of (measured) factors related to CHW data quality revealed that program-related determinants, rather than CHW characteristics were significantly associated with both data accuracy and reliability; however, lack of significance of some independent variables may be a function of CHW homogeneity or misreporting leading to small sub-sample sizes. Nevertheless, data accuracy was most strongly associated with timeliness (and completeness) – logging a household visit in the household register; and poor data reliability was consistently related to farther walking distance from the health center and greater number of sick children seen during April 2011. However, it was surprising that neither training nor supervision variables were significantly associated with data reliability or accuracy in the adjusted models. This may again be a result of homogeneity across health centers for training (CHWs are trained by health center); or, it may be a result of the quality or content of the training rather than whether or not a training was received. Therefore, we suggest that these factors can be addressed through strengthened training and supervision of CHWs using existing program resources and structures. In addition, we propose program supervisors carry out routine data quality assessments in order to improve CHW data quality and overall data use amongst all stakeholders.

In terms of broader significance to CHW programs in other settings, it is interesting to note that Rwanda while longer walking distance and higher patient volume were negatively associated with data reliability, neither of these was particularly high (90 minute median walking time and one (median) child seen during the month). Additionally, while we did not measure time spent carrying out various CHW tasks, though one group has estimated this to be roughly half the normal working day. It might be hypothesized that in countries where CHWs cover greater distances and populations and therefore time spent on CHW-related activities, data quality would be even worse. This could be magnified in settings where CHWs are not motivated through financial compensation or other means)(also not measured in this study) for their work.

Using the LQAS-based method for future routine data quality assessments

We found the LQAS-based method a practical one for routinely measuring data reliability of CHW village-level monthly reports in Rwanda. We have developed simple paper-based tools for health center level and above supervisors for this purpose. In the future, program managers should consider how CHW information will be used in order to determine optimum thresholds, frequency of assessments and indicators to evaluate.

Conversely, we considered this method to be too resource-intensive for measuring data accuracy of household registers on a routine basis. Instead, we suggest conducting baseline and annual or biannual evaluations and integrating data accuracy checks during routine cell- and health center-level supervision visits to CHWs and their households. Additionally, we recommend program managers devise a simple tool and accompanying training to facilitate CHWs tallying numbers from source data forms to the monthly reports.

While these recommendations are specific to the national program in Rwanda, we believe that any CHW program can benefit from routine data quality assessments and improvement of data quality through specific training and supervision using existing resources and structures.

7.2 Strengths and limitations

Strengths

This study had several strengths. Firstly, it employed a simple and practical methodology (LQAS) that can be replicated by program managers and supervisors to routinely assess CHW data quality over time; classifications of ‘good’ versus ‘poor’ quality data are both easy to understand and measure (improvement). Secondly, the assessment focused on data collected in a program that is being implemented globally to reduce U5 mortality (iCCM), filling a need to address monitoring concerns within iCCM (George et al., 2012a; WHO/UNICEF, 2012). Thirdly, the results of this study add to a nascent body of literature measuring quality of data collected and reported by CHWs – particularly as these data are increasingly used for program monitoring, management and evaluation at all levels. Fourthly, PBF systems are also gaining popularity in low-resource settings, though with mixed results (Ireland et al., 2011; Witter et al., 2012). The results of this study provide insight into the potential for purposeful misreporting within such a system.

The results of this study also fill a gap in the literature on factors related to CHW data quality. While there are several studies measuring different components of community level data quality, none went on to scientifically measure associations between data quality and potential independent variables -- this study looked at factors related to both accuracy and reliability of CHW data.

Limitations

This study focused on two measurable components of data quality – accuracy and reliability. There are others such as timeliness, completeness, etc. which may also have had different associated factors. However, accuracy and reliability are two of major components of data quality, without which, data use would not be desirable. In addition, CHWs in Rwanda are compensated through the PBF system in part for submitting complete and timely village-level monthly reports. According to De Naeyer (2011), measuring the completeness and timeliness of the monthly reports would have resulted in an almost 100% compliance rate.

Additionally, the study did not quantify types and counts of data recording and reporting errors (e.g. completeness, incorrect entries in registers or forms, etc.). However, data officers reported observations and took digital photos highlighting examples of the most common errors that were seen, including inconsistent, incomplete and illegible recording. These observations were communicated to and discussed with the MoH during dissemination of the study results to inform future action.

There was potential data collection and transcription error on the part of the data officers. This may have in turn led to an incorrect classification of data quality. For future assessments, those involved in data collection must maintain a high level of rigor and receive the training necessary to produce the LQAS data quality classifications. A paper-based tool currently under development can support extraction and classification, simplifying field implementation and removing one level of transcription from the process.

Another limitation was the reliance on self-report during the data accuracy assessment and CHW interviews. The household interview included verification of potentially sensitive information such as family planning methods used or place of delivery. External evaluators such as data officers may not be trusted to provide such potentially sensitive information; however, it appears that when there was discordance between the household register and information gathered from the household visits, it was the household register that under-reported indicators. Therefore, the household members seemed more likely to be forthcoming with sensitive information to external evaluators than to CHWs who live in their community. Furthermore, self-reported family planning information was almost always confirmed with the client-held family planning card.

Similarly, recall or response biases due to social context, program requirements or other reasons may have affected the measurement of program and CHW factors. However, outside of the supervision-related variables, interview questions were generally neutral.

If CHWs were notified too early and understood that they were going to be evaluated on the data quality of either the monthly report or the household register, they may have been able to complete or correct data entries accordingly. We tried to reduce this outcome by alerting CHWs as late as possible regarding the assessment activity, and describing it as a routine supervision visit.

selection criteria of CHWs and the way in which they are trained and supervised meant that some of these variables were homogeneous across CHWs (occupation, education level, civil status, cell supervision visit received and training received) and therefore may not have attained statistical significance in the analyses.

Another limitation may be the difference in time when the questionnaire was administered to CHWs by district (October 2011 to April 2012). This six-month difference may have affected analyses for certain time-sensitive variables, mainly among the CHW program variables such as type of training received in the last six months or time as a CHW. This can be observed in Table 24 where the percent of CHWs receiving iCCM training in the last six months versus ever differs by district; and mean number of years as CHW is more than a year less in southern Kayonza than northern Kayonza. However, these variables would all be relative in the district-specific analyses.

Finally, we may not have included all possible factors associated with CHW data quality. For example, the number of CHWs completing the village monthly report was two with the exception of southern Kayonza where anywhere from two to five CHWs completed a single report. This may have in turn impacted the accuracy of aggregation (the more CHWs, the worse the data), though we did include district in the adjusted model (and southern Kayonza did have worse data reliability than either Kirehe or northern

Kayonza). Another possible factor may have been time spent carrying out CHW-related activities per day or week. It might be that the more time spent, the worse the data quality, and that volume of patients may be one indicator of this. Finally, as noted previously, this study looked only at one type of factors – organizational – and others, namely technical and behavioral factors could certainly influence the quality of CHW data.

Generalizability

This study was carried out in Rwanda, where the national community health program is well-organized and -supported: there is a delineated supervision structure at every administrative level (from cell to health center to district and central levels) where information passes through on designated dates and in theory, there is a feedback mechanism; all tools are standardized which makes evaluating data quality much easier across sites; CHWs are accountable to the program through regular supervision and meetings, occasional evaluations and the PBF system; and there is political will to support and improve the program on an ongoing basis. As a country that has led the way in innovative CHW programs, Rwanda may be unique. Nevertheless, our results showed that there are still weaknesses in the quality of both data accuracy and reliability as well as factors related to these which may be more universally applicable.

Similarly, regardless of the specific structure and components of a CHW program, if CHW data are being utilized for program monitoring, management, evaluation or quality assurance purposes, the data need be both reliable and accurate. This study provides evidence in one particular setting for what factors might be responsible for poor or good data quality, as well as recommendations for addressing them. Further, it informs what may be included in future similar assessments in other settings. Finally, other similar studies corroborate our recommendations for interventions to address these factors (Admon et al., 2013; Mphatswe et al., 2012).

The data accuracy assessment was carried out in a PIH-supported district. The CHW program in southern Kayonza is enhanced through additional monthly compensation for CHWs, stricter criteria (higher education, dedicated position) for cell-level CHW supervisors, an additional health center-level clinically-trained CHW supervisor, and a smaller geographic catchment area per CHW with monthly household visits, amongst others. While these factors may have contributed to the level of data accuracy measured in this study, our results comparing data reliability across three districts show us that southern Kayonza experienced similar challenges as the two neighboring districts without PIH support.

While the data reliability assessment only reflects classifications from three [hospital] districts of approximately 40 in Rwanda, we purposefully selected districts with varying levels of partner support present in the country, making the results largely applicable to all districts.

We assessed data reliability of one program (iCCM) and one type of CHW (*binôme*). However, the iCCM program is one of the more resource-intensive in Rwanda and warrants more in depth understanding of data quality, particularly in light of better measurement of important child health indicators (WHO, 2011) and the importance of iCCM as a global strategy for achieving reduced child mortality (WHO/UNICEF, 2012). Additionally, the program uses algorithms and tools adapted from a generic set of guidelines thereby making these results potentially useful for other countries also implementing iCCM programs. Regarding applicability in Rwanda, maternal health CHWs have similarly structured data collection and reporting tools that could also be assessed for data quality.

7.3 Recommendations for future research

There are several recommendations for future research that come out of this study. Firstly, according to the conceptual framework upon which this work is based, we were only able to measure organizational determinants of data quality. Future studies could look at the others -- behavioral and technical determinants, either separately or altogether to determine their influence with respect to predicting data quality, particularly as we have noted that CHW motivation, form design and clarity and data use may impact it. This could include other possible but unmeasured independent variables such as time spent carrying out CHW tasks, literacy and numeracy, number of CHWs completing report form or quality of care (within iCCM or other program).

Secondly, future research may include measuring different components of data quality, combining them into one outcome measure or looking at the association between them. This includes timeliness, completeness, confidentiality and others.

Thirdly, this study only looked at baseline measures of accuracy and reliability. Future research could include carrying out recommended interventions (training, supervision, routine data quality checks) and re-assessing data quality at various time intervals as Admon et al. (2013) did in Malawi.

Finally, this study could be replicated in other settings where CHW program infrastructure is not as robust or supported, or at such scale as in Rwanda to test the generalizability of these results.

Chapter 8. Policy recommendations

Quality data are an integral part of any health and health information system. These data are used by decision makers to inform programming and policy towards the larger goal of improving health outcomes. Therefore, routinely monitoring data quality and understanding determinants of quality data are critical. This is true at any level, though particularly the community, where generally less-educated and -compensated health workers provide and document an increasing range of services.

The few studies that have been conducted to assess community-level data have shown that, like much facility-level data, it is often of sub-optimal quality (Admon et al., 2013; Forster et al., 2008; Garrib et al., 2008; Helleringer et al., 2010; Mahmood et al., 2010; Makombe et al., 2008; Maokola et al., 2011; Mate et al., 2009; Mavimbe et al., 2005; Mitsunaga T & Hedt-Gauthier B et al., 2013; Ndira et al., 2008; Otieno et al., 2011; Rowe et al., 2009). However, fewer studies provide scientific evidence of interventions to improve data quality at any level (Admon et al., 2013; Mphatswe et al., 2012), and those that do are limited to anecdotal observations as recommendations.

The policy recommendations that come out of this research are presented following the different components of the underlying conceptual framework and address the Rwanda-specific context as well as CHW programs and community health information systems more broadly.

Technical factors

An HIS is a necessary part of any CHW program, just as the inclusion of community-level information is essential in any routine HIS. However, health information systems are often developed without the integral input of data collectors. In the case of community health information systems, the level of participation of both the community and the CHWs in the development of the system can affect how data are collected and used. Including these key stakeholders in the process of developing a community HIS will increase buy-in and data use, with the aim of improving data quality. In Rwanda, for example, the iCCM forms and monthly report were not developed with the participation of either the community or the CHWs.

Moreover, the complexity of the data collection and reporting system anecdotally requires several hours of CHW time each month and five separate forms or reports to complete just for Rwanda's iCCM program alone (Ministry of Health (MoH)[Rwanda], 2011). The multi-level process of data aggregation creates many opportunities for data entry and transcription errors. All of these factors could impact the quality of data collected as part of the national CHW program in Rwanda and need to be systematically addressed.

The volume of data CHWs collect is large for the iCCM program alone (three forms, a register and report), and there is a fair amount of data transcription (from iCCM sick child form to iCCM register) and aggregation (from iCCM register to village monthly report) – both of which may contribute to poor data quality.

Though not formally measured in this study, these technical determinants directly affect data quality (Figure 1). Anecdotally, we observed this through unclear indicator definitions and our results showed over-reporting, and poor data aggregation that may be improved by the design and use of intermediate tally tools. The development of simple forms and reports with a minimum number of well-defined key data elements will encourage better data use and therefore data quality. While this applies to all levels of any HIS, it is especially important when employing CHWs with limited numeracy and writing skills who may have trouble accurately reporting their activities, or may be motivated to provide inaccurate reports by a variety of factors.

Behavioral factors

Similarly, behavioral determinants of quality data including the ability of supervisors to carry out simple data quality checks, and CHWs to use data they collect are not necessarily components of a CHW program such as iCCM. However, these should be built in as routine activities, thereby creating incentives to CHWs to collect and report on good quality data, facilitated by the technical factors described above and affected by organizational factors described below. This includes specific supervisor training on data quality issues (see below) as well as ensuring motivation to produce quality data unimpeded by inadequate time, training or financial compensation.

Organizational factors

Our results show that data reliability suffers the more sick children are seen by the CHW and the farther s/he has to walk to get to the health center. The former points to issues around form or report design, indicator definition, data aggregation (technical determinants addressed above) and general training and supervision (organizational determinants). That is, the unclear indicator definitions or the complexity or poor design of the tools may negatively affect how the CHW tallies indicator reports from the forms and register. The more children the CHW sees, the more tallying gets done, the worse the data quality (but could also point to the more CHWs involved in tallying a single report, the more prone to error in transcription). CHWs who live farther from the health center may also have higher patient volume, have to walk farther (and therefore take more time) to treat sick children (or carry out other CHW-related activities), attend fewer meetings or trainings at the health center (and therefore receive less potential feedback) (also leading to poorer data quality). Therefore, the Rwanda CHW program would do well to strengthen and support data aggregation through specific trainings around supportive supervision and data quality, particularly for those CHWs who live farther from the health center (and may not be as able to attend monthly meetings or trainings at the health center). Pallas et al. cite intensive training as an enabling factor for CHWs (Pallas et al., 2013); in Rwanda for example, the monthly report training is a day long with no practical exercies (poor data quality), whereas the household register training is two days long with many practical exercises (better data quality). Otherwise, cell or health center supervisors might provide more hands-on assistance during monthly meetings to support CHWs while they aggregate report data. Alternatively, limiting the scope of activities or decreasing geographic coverage of CHWs may help reduce time spent traveling as well as overall workload. Indeed, Pallas et al. state in their review of CHW programs that distance is a barrier to CHW programs (Pallas et al., 2013).

While receiving supervision or the duration of the supervision visit was not associated with data quality, it is possible that the content of these supervision visits may affect how well data are collected and reported. Therefore, interventions addressing what and how supervision is carried out may best improve CHW data quality – including effective feedback loops.

Process

The feedback mechanisms that are always diagrammed in supervision and data collection processes, but rarely actually carried out should be taken seriously and acted upon. Knowing that they are accountable for the data they report, CHWs may feel more central to the program goals.

Rwanda's CHW program has a well-developed supervision structure. The MoH can arm supervisors at all levels with training and tools to integrate routine CHW data quality checks into supportive supervision visits. This should include addressing technical, organizational and behavioral factors such as: simple checks for completeness, consistency and correctness; clarifying indicator definitions; ensuring availability of forms and reports; instant feedback; understanding and conveying of how and why data are collected and reported.

Regular and constructive feedback within the HIS will enable CHWs and supervisors to understand and use data they are collecting. Data use and feedback should take place at all levels of supervision, starting with the national level to the district, the district to the health centers, the health centers to both the cell and CHWs during monthly meetings, and the cell to the CHWs during monthly visits. This can be facilitated by the updated electronic district health information system and its capacity to display data graphically.

In southern Kayonza, PIH compensates cell supervisors with at least three years of secondary education whose sole job is to supervise all CHWs in their cell catchment area. In contrast, the MoH utilizes peer-selected *binômes* as cell coordinators. The additional work of ensuring good data quality among CHWs might be better operationalized by a PIH-like model. Alternatively, adding a second cell coordinator (e.g. to supervise maternal health CHWs only) may also relieve some of the duties from the *binôme* cell coordinator. Currently, supervisors do not receive any more or specialized training than their CHW counterparts. This should also be part of the improved supervision package.

Outputs

As an essential part of the health system, and potential contributors to the MDGs, CHWs are increasing in their geographic and programmatic scope. The expansion of iCCM programs is one such example, where CHWs are carrying out curative activities traditionally provided at health facilities. As a result, donors and program managers are assessing the effect CHW activities may have on health outcomes and impacts such as maternal and child morbidity and mortality. This in part relies on information CHWs collect and report, highlighting the importance of data accuracy and reliability. This holds true for programs that use CHWs specifically as data collectors such as in humanitarian emergency settings and for any type of surveillance activity.

Rwanda's PBF system has been shown to be an effective means of improving quality of care in health centers and hospitals (Basinga et al., 2011). While data quality audits are a routine part of facility-based PBF, this is not the case at the community-level where the GoR employs the PBF system to incentivize otherwise unpaid CHWs to carry out an increasing number of tasks. The LQAS-based methodology of assessing data reliability could be used to routinely measure the quality of select PBF indicators, currently only counted, not verified (De Naeyer, 2011; Ministry of Health (MoH)[Rwanda], 2009b; MoH [Rwanda] Community Health Desk, 2013). In order to do so, the GoR must decide how reliable the data need to be for their various uses: paying into CHW cooperatives; program monitoring and management; and quality improvement activities. Relevant indicators and thresholds for 'poor' and 'good' quality data can then be selected. Once data quality has been established, it would then be possible for program managers to assess the quality of services provided with greater certainty.

In southern Kayonza district, CHWs were able to accurately record and update data in their household registers. By integrating this data collection tool into SISCom, the GoR would have access to population-based information on a routine basis. This includes being able to utilize actual numbers rather than estimates for denominators such as women of reproductive age, children U5 and total population. At the time of research, Rwanda did not have a robust system for collecting and reporting mortality data outside of health facilities (though it was developing a community-based verbal autopsy reporting structure), the register could additionally provide accurate numbers on deaths at the household level. In turn, SISCom program indicators could provide a more accurate picture between censuses. Rather than requiring monthly totals of target populations, having health center supervisors oversee and support CHWs tally numbers of children U5, women of reproductive age and total population on an annual basis may be more efficient and yield more accurate totals.

There are currently 13 tables in the household register. For national rollout, reducing the number of tables and simplifying the number and content of the data elements may also ensure greater accuracy.

By holistically addressing the different but complementary pieces of the conceptual framework, CHW program managers and stakeholders may better measure important health outcomes and impact, by ensuring use of data of sufficient quality.

Chapter 9. References

Admon A. J., Bazile J., Makungwa H., et al. (2013) Assessing and improving data quality from community health workers: a successful intervention in Neno, Malawi. *Public Health Action,* 3(1), 56-59.

Allotey P. A., & Reidpath D. (2000) Information quality in a remote rural maternity unit in Ghana. *Health Policy Plan,* 15(2), 170-176.

Aqil A., Lippeveld T., & Hozumi D. (2009) PRISM framework: a paradigm shift for designing, strengthening and evaluating routine health information systems. *Health Policy Plan,* 24(3), 217-228.

Bang A. T., Bang R. A., Stoll B. J., et al. (2005) Is home-based diagnosis and treatment of neonatal sepsis feasible and effective? Seven years of intervention in the Gadchiroli field trial (1996 to 2003). *J Perinatol,* 25 Suppl 1S62-71.

Banteyerga H. (2011) Ethiopia's health extension program: improving health through community involvement. *MEDICC Rev,* 13(3), 46-49.

Baqui A. H., Arifeen S. E., Williams E. K., et al. (2009) Effectiveness of Home-Based Management of Newborn Infections by Community Health Workers in Rural Bangladesh. *Pediatr Infect Dis J,* 28(4), 304-310.

Basinga P. (2011) Impact evaluation of community performance--based financing programs in Rwanda: 2010 baseline study results. Kigali, Rwanda: Presentation at workshop: Evidence to policy: using impact evaluation and data for informed decision making.

Basinga P., Gertler P. J., Binagwaho A., et al. (2011) Effect on maternal and child health services in Rwanda of payment to primary health-care providers for performance: an impact evaluation. *Lancet,* 377(9775), 1421-1428.

Berman P. A., Gwatkin D. R., & Burger S. E. (1987) Community-based health workers: head start or false start towards health for all? *Soc Sci Med,* 25(5), 443-459.

Bhutta Z. A., Chopra M., Axelson H., et al. (2010a) Countdown to 2015 decade report (2000-10): taking stock of maternal, newborn, and child survival. *Lancet,* 375(9730), 2032-2044.

Bhutta Z. A., Darmstadt G. L., Hasan B. S., et al. (2005) Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. *Pediatrics,* 115(2 Suppl), 519-617.

Bhutta Z. A., Lassi Z. S., Pariyo G. W., et al. (2010b) Global experience of community health workers for delivery of health-related Millennium Development Goals: a systematic review, country case studies, and recommendations for integration into national health systems. Geneva: WHO/Global Health Workforce Alliance.

Bhutta Z. A., Zaidi A. K., Thaver D., et al. (2009) Management of newborn infections in primary care settings: a review of the evidence and implications for policy? *Pediatr Infect Dis J,* 28(1 Suppl), S22-30.

Bosch-Capblanch X., Ronveaux O., Doyle V., et al. (2009) Accuracy and quality of immunization information systems in forty-one low income countries. *Trop Med Int Health,* 14(1), 2-10.

Bowden S., Braker K., Checchi F., et al. (2012) Implementation and utilisation of community-based mortality surveillance: a case study from Chad. *Confl Health,* 6(1), 11.

Braa J., Heywood A., & Sahay S. (2012) Improving quality and use of data through data-use workshops: Zanzibar, United Republic of Tanzania. *Bull World Health Organ,* 90(5), 379-384.

Brunie A., Hoke T. H., & Razafindravony B. (2011) [Community-based distribution of injectable contraceptives in an African setting: community trial in Madagascar]. *Sante,* 21(1), 21-26.

Caleo G. M., Sy A. P., Balandine S., et al. (2012) Sentinel site community surveillance of mortality and nutritional status in southwestern Central African Republic, 2010. *Popul Health Metr,* 10(1), 18.

Cavalcante S. C., Soares E. C., Pacheco A. G., et al. (2007) Community DOT for tuberculosis in a Brazilian favela: comparison with a clinic model. *Int J Tuberc Lung Dis,* 11(5), 544-549.

Christopher J. B., Le May A., Lewin S., et al. (2011) Thirty years after Alma-Ata: a systematic review of the impact of community health workers delivering curative interventions against malaria, pneumonia and diarrhoea on child mortality and morbidity in sub-Saharan Africa. *Hum Resour Health,* 9(1), 27.

CHW Technical Taskforce. (2013) One million community health workers: technical taskforce report. New York, NY: The Earth Institute, Columbia University.

Clarke M., Dick J., Zwarenstein M., et al. (2005) Lay health worker intervention with choice of DOT superior to standard TB care for farm dwellers in South Africa: a cluster randomised control trial. *Int J Tuberc Lung Dis,* 9(6), 673-679.

Coffey P. S., Sharma J., Gargi K. C., et al. (2012) Feasibility and acceptability of gentamicin in the Uniject prefilled injection system for community-based treatment of possible neonatal sepsis: the experience of female community health volunteers in Nepal. *J Perinatol,* 32(12), 959-965.

Concern Worldwide. (2006) Expanded Impact Child Survival Program: October 2006 – September 2011: detailed implementation plan: *kabeho mwana*: Gisagara, Kirehe, Ngoma, Nyamagabe, Nyamasheke, and Nyaraguru Districts, Rwanda: a partnership of Concern Worldwide, the International Rescue Committee, and World Relief. New York.

Crispin N., Wamae A., Ndirangu M., et al. (2012) Effects of Selected Socio-Demographic Characteristics of Community Health Workers on Performance of Home Visits during Pregnancy: A Cross-Sectional Study in Busia District, Kenya. *Glob J Health Sci,* 4(5), 78-90.

Darmstadt G. L., Bhutta Z. A., Cousens S., et al. (2005) Evidence-based, cost-effective interventions: how many newborn babies can we save? *Lancet,* 365(9463), 977-988.

Data verification thematic working group. (2011) Data verification, *presented at Evidence to policy: using impact evaluation and data for informed decision making workshop*. Kigali, Rwanda: Rwanda Minstry of Health, World Bank, National University of Rwanda School of Public Health.

De Naeyer L. (2011) National community health performance-based financing: design and implementation of supply-side model, *PBF workshop*. Bujumbura, Burundi.

de Sousa A., Tiedje K. E., Recht J., et al. (2012) Community case management of childhood illnesses: policy and implementation in Countdown to 2015 countries. *Bull World Health Organ,* 90(3), 183-190.

Debay M., Tantri A., Tulenko K., et al. (2003) On the design of community-based health information systems (pp. 46: available at http://www.childsurvival.com/documents/CSTS/C-HIS_Final.pdf). Calverton, MD: The Child Survival Technical Support Project.

Derman R. J., Kodkany B. S., Goudar S. S., et al. (2006) Oral misoprostol in preventing postpartum haemorrhage in resource-poor communities: a randomised controlled trial. *Lancet,* 368(9543), 1248-1253.

Dodge H. F., & Romig H. G. (1929) A method of sampling inspection *Bell System Technical Journal,* 8(4), 613-631.

Drobac P. C., Basinga P., Condo J., et al. (2013) Comprehensive and integrated district health systems strengthening: the Rwanda Population Health Implementation and Training (PHIT) Partnership. *BMC Health Serv Res,* 13 Suppl 2S5.

Edward A., Ernst P., Taylor C., et al. (2007) Examining the evidence of under-five mortality reduction in a community-based programme in Gaza, Mozambique. *Trans R Soc Trop Med Hyg,* 101(8), 814-822.

Farmer P., Leandre F., Mukherjee J., et al. (2001) Community-based treatment of advanced HIV disease: introducing DOT-HAART (directly observed therapy with highly active antiretroviral therapy). *Bull World Health Organ,* 79(12), 1145-1151.

Forster M., Bailey C., Brinkhof M., et al. (2008) Electronic medical record systems, data quality and loss to follow-up: survey of antiretroviral therapy programmes in resource-limited settings. *Bulletin of the World Health Organization,* 86939-947.

Franke M. F., Kaigamba F., Socci A. R., et al. (2013) Improved retention associated with community-based accompaniment for antiretroviral therapy delivery in rural Rwanda. *Clin Infect Dis,* 56(9), 1319-1326.

Garrib A., Stoops N., McKenzie A., et al. (2008) An evaluation of the District Health Information System in rural South Africa. *South African Medical Journal,* 98(7), 549-552.

George A., Menotti E. P., Rivera D., et al. (2009) Community case management of childhood illness in Nicaragua: transforming health systems in underserved rural areas. *J Health Care Poor Underserved,* 20(4 Suppl), 99-115.

George A., Young M., Nefdt R., et al. (2012a) Community case management of diarrhea, malaria and pneumonia: tracking science to policy and practice in sub-Saharan Africa. New York: UNICEF.

George A., Young M., Nefdt R., et al. (2012b) Community health workers providing government community case management for child survival in sub-Saharan Africa: who are they and what are they expected to do? *Am J Trop Med Hyg,* 87(5 Suppl), 85-91.

Gilroy K., Winch P. J., Diawara A., et al. (2004) Impact of IMCI training and language used by provider on quality of counseling provided to parents of sick children in Bougouni District, Mali. *Patient Educ Couns,* 54(1), 35-44.

Gilroy K. E., Callaghan-Koru J. A., Cardemil C. V., et al. (2012) Quality of sick child care delivered by Health Surveillance Assistants in Malawi. *Health Policy Plan*.

Gimbel S., Micek M., Lambdin B., et al. (2011) An assessment of routine primary care health information system data quality in Sofala Province, Mozambique. *Popul Health Metr,* 912.

Global Health Workforce Alliance. (2012) Global Health Workforce Alliance: strategy 2013-2016: advancing the health workforce agenda within universal health coverage Geneva: WHO/Global Health Workforce Alliance.

Government of Rwanda Ministry of Health (MoH). (2009) Health sector strategic plan: July 2009 - June 2012 (HSSP II). Rwanda: MoH.

Greer G., Akinpelumi A., Madueke L., et al. (2004) Improving management of childhood malaria in Nigeria and Uganda by improving practices of patent medicine vendors. Arlington, VA: BASICS II for the United States Agency for International Development.

Hafeez A., Mohamud B. K., Shiekh M. R., et al. (2011) Lady health workers programme in Pakistan: challenges, achievements and the way forward. *J Pak Med Assoc,* 61(3), 210-215.

Haines A., Sanders D., Lehmann U., et al. (2007) Achieving child survival goals: potential contribution of community health workers. *Lancet,* 369(9579), 2121-2131.

Health Systems 20/20 Project. (2012) Health Extension Program: an innovative solution to public health challenges of Ethiopia: a case study. Bethesda MD: Abt Associates Inc.

Health worker time allocation thematic working group. (2011) Health worker time allocation, *presented at Evidence to policy: using impact evaluation and data for informed decision making workshop*. Kigali, Rwanda: Rwanda Minstry of Health, World Bank, National University of Rwanda School of Public Health.

Hedt-Gauthier B. L., Mitsunaga T., Hund L., et al. (2013) The effect of clustering on Lot Quality Assurance Sampling: a probabilistic model to correctly calculate sample sizes with an illustration of community health worker data quality assessments. *Emerging Themes in Epidemiology,* 10(11).

Hedt-Gauthier B. L., Mitsunaga T., Hund L., et al. (Under review) The effect of clustering on Lot Quality Assurance Sampling: a probabilistic model to correctly calculate sample sizes with an illustration of community health worker data quality assessments. *Emerging Themes in Epidemiology*.

Hedt-Gauthier B. L., Tenthani L., Mitchell S., et al. (2012) Improving data quality and supervision of antiretroviral therapy sites in Malawi: an application of Lot Quality Assurance Sampling. *BMC Health Serv Res,* 12196.

Helleringer S., Frimpong J. A., Phillips J. F., et al. (2010). *Abstract: Operational study of the quality of health data aggregated by community health workers in the Upper East Region of Ghana.* Paper presented at the American Public Health Association Annual Meeting, November 7-10, 2010, Washington, DC.

Hoke T. H., Wheeler S. B., Lynd K., et al. (2012) Community-based provision of injectable contraceptives in Madagascar: 'task shifting' to expand access to injectable contraceptives. *Health Policy Plan,* 27(1), 52-59.

Hong R., Ayad M., Rutstein S., et al. (2009) Childhood mortality in Rwanda: levels, trends, and differentials; further analysis of the Rwanda Demographic and Health Surveys, 1992-2007/08, *DHS further analysis reports No. 66*. Calverton, Maryland, USA: ICF Macro.

Hopkins H., Talisuna A., Whitty C. J., et al. (2007) Impact of home-based management of malaria on health outcomes in Africa: a systematic review of the evidence. *Malar J,* 6134.

IRC. (2000) Rwanda child survival grant XV, Kibungo health region: detailed implementation plan: IRC.

Ireland M., Paul E., & Dujardin B. (2011) Can performance-based financing be used to reform health systems in developing countries? *Bull World Health Organ,* 89(9), 695-698.

John Snow Inc. (JSI). (2013). Supply chains for community case management (SC4CCM). Retrieved December 4, 2013, from http://sc4ccm.jsi.com/countries/rwanda/

Kalach J. (2011) Saving Mothers and Newborn Lives in the Community Using RapidSMS Technology - Experience from Musanze District of Rwanda. Kigali, Rwanda: Presentation at International Conference on Community Health.

Källander K., Tibenderana K. J., Akpogheneta J. O., et al. (2013) Mobile Health (mHealth) Approaches and Lessons for Increased Performance and Retention of

Community Health Workers in Low- and Middle-Income Countries: A Review. *J Med Internet Res,* 15(1), e17.

Kelly J. M., Osamba B., Garg R. M., et al. (2001) Community health worker performance in the management of multiple childhood illnesses: Siaya District, Kenya, 1997-2001. *Am J Public Health,* 91(10), 1617-1624.

Khanal S., Sharma J., Gc V. S., et al. (2011) Community health workers can identify and manage possible infections in neonates and young infants: MINI--a model from Nepal. *J Health Popul Nutr,* 29(3), 255-264.

Krueger K., Akol A., Wamala P., et al. (2011) Scaling up community provision of injectables through the public sector in Uganda. *Stud Fam Plann,* 42(2), 117-124.

Lainez Y. B., Wittcoff A., Mohamud A. I., et al. (2012) Insights from community case management data in six sub-Saharan African countries. *Am J Trop Med Hyg,* 87(5 Suppl), 144-150.

Lehmann U., & Sanders D. (2007) Community health workers: what do we know about them? The state of the evidence on programmes, activities, costs and impact on health outcomes of using community health workers. Geneva: World Health Organization.

Lewin S., Munabi-Babigumira S., Glenton C., et al. (2010) Lay health workers in primary and community health care for maternal and child health and the management of infectious diseases. *Cochrane Database Syst Rev*(3), CD004015.

Liu A., Sullivan S., Khan M., et al. (2011) Community health workers in global health: scale and scalability. *Mt Sinai J Med,* 78(3), 419-435.

Liu L., Johnson H. L., Cousens S., et al. (2012) Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet,* 379(9832), 2151-2161.

Lwanga S. K., Lemeshow S., & World Health Organization. (1991). *Sample size determination in health studies : a practical manual*. Geneva: World Health Organization.

Mahmood S., & Ayub M. (2010) Accuracy of primary health care statistics reported by community based lady health workers in district Lahore. *J Pak Med Assoc,* 60(8), 649-653.

Makombe S. D., Hochgesang M., Jahn A., et al. (2008) Assessing the quality of data aggregated by antiretroviral treatment clinics in Malawi. *Bull World Health Organ,* 86(4), 310-314.

Malarcher S., Meirik O., Lebetkin E., et al. (2011) Provision of DMPA by community health workers: what the evidence shows. *Contraception,* 83(6), 495-503.

Maokola W., Willey B., Shirima K., et al. (2011) Enhancing the routine health information system in rural southern Tanzania: successes, challenges and lessons learned. *Tropical Medicine and International Health,* 16(6), 721-730.

Mate K. S., Bennett B., Mphatswe W., et al. (2009) Challenges for routine health system data management in a large public programme to prevent mother-to-child HIV transmission in South Africa. *PLoS One,* 4(5).

Mavimbe J., Braa J., & Bjune G. (2005) Assessing immunization data quality from routine reports in Mozambique. *BMC Public Health,* 5(108), 1-8.

McGorman L., Marsh D. R., Guenther T., et al. (2012) A Health Systems Approach to Integrated Community Case Management of Childhood Illness: Methods and Tools. *The American Journal of Tropical Medicine and Hygiene,* 87(5 Suppl), 69-76.

MEASURE Evaluation. (2007) Assessing M&E systems for data quality: presented at USAID Mini University. George Washington University, Washington DC.

MEASURE Evaluation. (2010) Community-Level Program Information Reporting for HIV/AIDS Programs: introduction. Chapel Hill, NC: MEASURE Evaluation.

MEASURE Evaluation. (2012) Data Demand and Information Use in the Health Sector: Case Study Series. Chapel Hill, NC: MEASURE Evaluation.

Mechael P., Batavia H., Kaonga N., et al. (2010) Barriers and Gaps Affecting mHealth in Low and Middle Income Settings: Policy White Paper: The mHealth Alliance.

Millennium Villages Project. (2012). Introduction: ChildCount+ v2.0(g) documentation. Retrieved December 6, 2012, from http://mvpdev.github.com/rapidsms/intro.html

Ministry of Health (MoH) [Rwanda]. (2008) National community health policy. Rwanda: MoH.

Ministry of Health (MoH)[Rwanda]. (2008) Procedures manual for the Rwanda community health information system (SISCom): section I: data recording and reporting; version 1.1. Rwanda: MoH.

Ministry of Health (MoH)[Rwanda]. (2009a) Community IMCI / Community case management: evaluation report of community health workers performance. Rwanda: MoH.

Ministry of Health (MoH)[Rwanda]. (2009b) Community performance-based financing: user guide. Rwanda: MoH.

Ministry of Health (MoH)[Rwanda]. (2011) Trainer's guide: "integrated management of child illness" community case management. Rwanda: MoH.

Mitsunaga T & Hedt-Gauthier B, Ngizwenayo E., Bertrand Farmer D., et al. (2012a). *Improving child health data quality by community health workers: a routine system and baseline results.* Paper presented at the Annual International Child Health Conference Kigali, Rwanda.

Mitsunaga T & Hedt-Gauthier B, Ngizwenayo E., Bertrand Farmer D., et al. (2012b). *Utilizing Community Health Worker Data for Health Systems Strengthening: Routine Data Quality Assessments and Baseline Results from Rwanda.* Paper presented at the Second Global Symposium on Health Systems Research Beijing, China.

Mitsunaga T & Hedt-Gauthier B, Ngizwenayo E., Bertrand Farmer D., et al. (2013) Utilizing community health worker data for program management and evaluation: systems for data quality assessments and baseline results from Rwanda. *Social Science & Medicine,* 85(0), 87-92.

MobileActive.org. (2012). MobileActive.org - Mobile Data Collection Inventory

. Retrieved December 6, 2012, from https://docs.google.com/spreadsheet/ccc?key=0ApuAPTf-vi_1dDdVX1h5VlowRDE0b0xyRFBsdXBfZEE&hl=en#gid=14

MoH [Rwanda]. (2008a) National community health policy. Rwanda: MoH.

MoH [Rwanda]. (2008b) Procedures manual for the Rwanda community health information system (SISCom): section I: data recording and reporting; version 1.1. Rwanda: MoH.

MoH [Rwanda]. (2009) Community performance-based financing: user guide. Rwanda: MoH.

MoH [Rwanda]. (2011a) Report of the rapid evaluation of the national community integrated management of childhood illnesses (c-IMCI) program (July 2010). Kigali: MoH.

MoH [Rwanda]. (2011b) Trainer's guide: "integrated management of child illness" community case management. Rwanda: MoH.

MoH [Rwanda]. (2013). HMIS [Health management information system]. Retrieved June 17, 2013, from http://moh.gov.rw/english/?page_id=2221

MoH [Rwanda] Community Health Desk. (2013) Community PBF [performance-based financing] in Rwanda. Presentation.

Mphatswe W., Mate K. S., Bennett B., et al. (2012) Improving public health information: a data quality intervention in KwaZulu-Natal, South Africa. *Bull World Health Organ,* 90176-182.

Mugeni C. (2011) Community health program in Rwanda overview. Kigali, Rwanda: Presentation at workshop: Evidence to policy: using impact evaluation and data for informed decision making.

Mugeni C. (2012) *Community Health Desk, Rwanda Ministry of Health*. Personal Communication.

Munoz M., Finnegan K., Zeladita J., et al. (2010) Community-based DOT-HAART accompaniment in an urban resource-poor setting. *AIDS Behav,* 14(3), 721-730.

National Institute of Statistics of Rwanda (NISR). (2012). Featured indicators. Retrieved September 25, 2012, from http://statistics.gov.rw/indicators/featured

National Institute of Statistics of Rwanda (NISR), Ministry of Finance and Economic Planning (MINECOFIN), MoH [Rwanda], et al. (2012) Rwanda Demographic and Health Survey 2010 Calverton, Maryland, USA: NISR, MoH and ICF International.

Ndira S. P., Rosenberger K. D., & Wetter T. (2008) Assessment of data quality of and staff satisfaction with an electronic health record system in a developing country (Uganda): a qualitative and quantitative comparative study. *Methods Inf Med,* 47(6), 489-498.

Nkusi E. (2010) Generic DQA tool development and training rollout. Kigali, Rwanda.

Nutley T. (2012) Improving data use in decision making: an intervention to strengthen health systems. Chapel Hill, NC: MEASURE Evaluation.

Olives C., Pagano M., Deitchler M., et al. (2009) Cluster designs to assess the prevalence of acute malnutrition by lot quality assurance sampling: a validation study by computer simulation. *J R Stat Soc Ser A Stat Soc,* 172(2), 495-510.

Otieno C. F., Kaseje D., Ochieng B. M., et al. (2011) Reliability of community health worker collected data for planning and policy in a peri-urban area of Kisumu, Kenya. *J Community Health,* 37(1), 48-53.

Otwombe K. N., Wanyungu J., Nduku K., et al. (2007) Improving national data collection systems from voluntary counselling and testing centres in Kenya. *Bull World Health Organ,* 85315-318.

Oxford Policy Management. (2009) Lady health worker programme: fourth external evaluation for the national programme for family planning and primary health care: quantitative survey report Oxford Policy Management.

Pagano M., & Valadez J. J. (2010) Commentary: Understanding practical lot quality assurance sampling. *Int J Epidemiol,* 39(1), 69-71.

Pallas S. W., Minhas D., Perez-Escamilla R., et al. (2013) Community health workers in low- and middle-income countries: what do we know about scaling up and sustainability? *Am J Public Health,* 103(7), e74-82.

Perry H., Freeman P., Gupta S., et al. (2009) A review of the evidence: how effective is community-based primary health care in improving the health of children? , *Summary findings: report to the expert review panel*: Community-based primary health care working group, International Health section American Public Health Association.

Perry H., & Zulliger R. (2012) How effective are community health workers? An overview of current evidence with recommendations for strengthening community health worker programs to accelerate progress in achieving the health-related Millennium Development Goals Baltimore, MD: Johns Hopkins Bloomberg School of Public Health.

Pezzoli L., Andrews N., & Ronveaux O. (2010) Clustered lot quality assurance sampling to assess immunisation coverage: increasing rapidity and maintaining precision. *Trop Med Int Health,* 15(5), 540-546.

Prata N., Gessessew A., Cartwright A., et al. (2011) Provision of injectable contraceptives in Ethiopia through community-based reproductive health agents. *Bull World Health Organ,* 89(8), 556-564.

Prata N., Quaiyum M. A., Passano P., et al. (2012) Training traditional birth attendants to use misoprostol and an absorbent delivery mat in home births. *Soc Sci Med,* 75(11), 2021-2027.

Qiang C., Yamamichi M., Hausman V., et al. (2011) Mobile Applications for the Health Sector. Washington DC: World Bank.

Rich M. L., Miller A. C., Niyigena P., et al. (2012) Excellent clinical outcomes and high retention in care among adults in a community-based HIV treatment program in rural Rwanda. *J Acquir Immune Defic Syndr,* 59(3), e35-42.

Robertson S. E., Anker M., Roisin A. J., et al. (1997) The lot quality technique: a global review of applications in the assessment of health services and disease surveillance. *World Health Stat Q,* 50(3-4), 199-209.

Robertson S. E., & Valadez J. J. (2006) Global review of health care surveys using lot quality assurance sampling (LQAS), 1984-2004. *Social Science & Medicine,* 631648-1660.

Rowe A. K., Kachur S. P., S.S. Y., et al. (2009) Caution is required when using health facility-based data to evaluate the health impact of malaria control efforts in Africa. *Malar J,* 8(209), 1-3.

Rowe A. K., Lama M., Onikpo F., et al. (2002) Design effects and intraclass correlation coefficients from a health facility cluster survey in Benin. *International Journal for Quality in Health Care,* 14(6), 521-523.

Rowe S. Y., Kelly J. M., Olewe M. A., et al. (2007a) Effect of multiple interventions on community health workers' adherence to clinical guidelines in Siaya district, Kenya. *Trans R Soc Trop Med Hyg,* 101(2), 188-202.

Rowe S. Y., Olewe M. A., Kleinbaum D. G., et al. (2007b) Longitudinal analysis of community health workers' adherence to treatment guidelines, Siaya, Kenya, 1997-2002. *Trop Med Int Health,* 12(5), 651-663.

Schneider H., & Lehmann U. (2010) Lay health workers and HIV programmes: implications for health systems. *AIDS Care,* 22 Suppl 160-67.

Seguy N., Hladik W., Munyisia E., et al. (2006) Can data from programs for the prevention of mother-to-child transmission of HIV be used for HIV surveillance in Kenya? *Public Health Reports,* 121695-702.

Shah R., Munos M. K., Winch P. J., et al. (2010) Community-based health workers achieve high coverage in neonatal intervention trials: a case study from Sylhet, Bangladesh. *J Health Popul Nutr,* 28(6), 610-618.

Shin S., Furin J., Bayona J., et al. (2004) Community-based treatment of multidrug-resistant tuberculosis in Lima, Peru: 7 years of experience. *Soc Sci Med,* 59(7), 1529-1539.

Smith J. M., Gubin R., Holston M. M., et al. (2013) Misoprostol for postpartum hemorrhage prevention at home birth: an integrative review of global implementation experience to date. *BMC Pregnancy Childbirth,* 1344.

Stanback J., Spieler J., Shah I., et al. (2010) Community-based health workers can safely and effectively administer injectable contraceptives: conclusions from a technical consultation. *Contraception,* 81(3), 181-184.

StataCorp. (2007) Stata Statistical Software: Release 10. College Station, TX: StataCorp LP.

Stewart J. C., Schroeder D. G., Marsh D. R., et al. (2001) Assessing a computerized routine health information system in Mali using LQAS. *Health Policy Plan,* 16(3), 248-255.

Tamrat T., & Kachnowski S. (2011) Special delivery: an analysis of mHealth in maternal and newborn health programs and their outcomes around the world. *Matern Child Health J,* 16(5), 1092-1101.

The Global Fund. (2008) Data quality audit tool: guidelines for implementation. Geneva: The Global Fund.

The Global Fund. (2009) Monitoring and evaluation toolkit. Geneva: The Global Fund.

The Global Fund, OGAC, PEPFAR, et al. (2008) Routine data quality assessment tool (RDQA): guidelines for implementation for HIV, TB & malaria programs

Tomlinson M., Solomon W., Singh Y., et al. (2009) The use of mobile phones as a data collection tool: a report from a household survey in South Africa. *BMC Med Inform Decis Mak,* 951.

United Nations. (2013) A new global partnership: eradicate poverty and transform economies through sustainable development: the report of the high-level panel of eminent persons on the post-2015 development agenda. New York, NY: United Nations.

United Nations Statistics Division. (2012a). Millennium Development Goals Indicators: the official United Nations site for the MDG indicators: About the Millennium Development Goals Indicators. Retrieved 27/9/2012

United Nations Statistics Division. (2012b). Millennium Development Goals Indicators: the official United Nations site for the MDG indicators: official list of MDG indicators. Retrieved 27/9/2012

Valadez J. J. (1991). *Assessing child survival programs in developing countries: testing lot quality assurance sampling*. Boston, Mass.: Dept. of Population and International Health, Harvard School of Public Health ; Distributed by Harvard University Press.

van den Boogaard J., Lyimo R., Irongo C. F., et al. (2009) Community vs. facility-based directly observed treatment for tuberculosis in Tanzania's Kilimanjaro Region. *Int J Tuberc Lung Dis,* 13(12), 1524-1529.

Viswanathan M., Kraschnewski J. L., Nishikawa B., et al. (2010) Outcomes and costs of community health worker interventions: a systematic review. *Med Care,* 48(9), 792-808.

Wandwalo E., Kapalata N., Egwaga S., et al. (2004) Effectiveness of community-based directly observed treatment for tuberculosis in an urban setting in Tanzania: a randomised controlled trial. *Int J Tuberc Lung Dis,* 8(10), 1248-1254.

WHO. (1978). Declaration of Alma-Ata: International Conference on Primary Health Care, Alma-Ata, USSR, 6-12 September 1978. Retrieved May 24, 2008, from http://www.who.int/hpr/NPH/docs/declaration_almaata.pdf

WHO. (2000) The world health report 2000: health systems: improving performance. Geneva, Switzerland: WHO.

WHO. (2007) Everybody's business : strengthening health systems to improve health outcomes : WHO's framework for action. Geneva: WHO.

WHO. (2008a) Assessing the national health information system: an assessment tool: version 4.00. Geneva: WHO.

WHO. (2008b) Health Metrics Network: framework and standards for country health information systems (Second ed.). Geneva: WHO.

WHO. (2011) Keeping promises, measuring results: Commission on information and accountability for Women's and Children's Health. Geneva: WHO.

WHO, & Global Health Workforce Alliance. (2010). *Global experience of community health workers for delivery of health-related Millennium Development Goals: a systematic review, country case studies, and recommendations for integration into national health systems*. Geneva: WHOo. Document Number)

WHO study group on CHWs. (1989) Strengthening the performance of community health workers in primary health care. Report of a WHO Study Group. *World Health Organ Tech Rep Ser,* 7801-46.

WHO/UNICEF. (2004a). *Joint Statement: Clinical Management of Acute Diarrhoea*. Geneva and New York: WHO.FCH/CAH/04.07o. Document Number)

WHO/UNICEF. (2004b). *Joint Statement: Management of Pneumonia in Community Settings*. Geneva and New York: WHO.FCH/CAH/04.06o. Document Number)

WHO/UNICEF. (2012) Joint Statement: Integrated Community Case Management. Geneva: WHO and New York: UNICEF.

Witter S., Fretheim A., Kessy F. L., et al. (2012) Paying for performance to improve the delivery of health interventions in low- and middle-income countries. *Cochrane Database Syst Rev,* 2CD007899.

World Health Organization (WHO) and Global Health Workforce Alliance. (2010) Global experience of community health workers for delivery of health-related Millennium Development Goals: a systematic review, country case studies, and recommendations for integration into national health systems. Geneva: WHO.

Young M., Wolfheim C., Marsh D. R., et al. (2012) World Health Organization/United Nations Children's Fund Joint Statement on Integrated Community Case Management: An Equity-Focused Strategy to Improve Access to Essential Treatment Services for Children. *Am J Trop Med Hyg,* 87(5 Suppl), 6-10.

Zvavamwe Z., & Ehlers V. J. (2009) Experiences of a community-based tuberculosis treatment programme in Namibia: a comparative cohort study. *Int J Nurs Stud,* 46(3), 302-309.

Chapter 10. Appendices

10.1 Millennium development goals and indicators

Millennium Development Goals (MDGs)	
Goals and Targets (from the Millennium Declaration)	**Indicators for monitoring progress**
Goal 4: Reduce child mortality	
Target 4.A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	4.1 Under-five mortality rate 4.2 Infant mortality rate 4.3 Proportion of 1 year-old children immunised against measles
Goal 5: Improve maternal health	
Target 5.A: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio	5.1 Maternal mortality ratio 5.2 Proportion of births attended by skilled health personnel
Target 5.B: Achieve, by 2015, universal access to reproductive health	5.3 Contraceptive prevalence rate 5.4 Adolescent birth rate 5.5 Antenatal care coverage (at least one visit and at least four visits) 5.6 Unmet need for family planning
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 6.A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	6.1 HIV prevalence among population aged 15-24 years 6.2 Condom use at last high-risk sex 6.3 Proportion of population aged 15-24 years with comprehensive correct knowledge of HIV/AIDS 6.4 Ratio of school attendance of orphans to school attendance of non-orphans aged 10-14 years
Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it	6.5 Proportion of population with advanced HIV infection with access to antiretroviral drugs
Target 6.C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	6.6 Incidence and death rates associated with malaria 6.7 Proportion of children under 5 sleeping under insecticide-treated bednets 6.8 Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs 6.9 Incidence, prevalence and death rates associated with tuberculosis 6.10 Proportion of tuberculosis cases detected and cured under directly observed treatment short course

Source: (United Nations Statistics Division, 2012)

10.2 Activities carried out by binômes in Rwanda

Preventive services	Curative services	Promotive services
• Community sensitization on prevention of common diseases: malaria, diarrhea, ARI, etc. • Education for prevention of sexually transmitted infections • Community mobilization, sensitization and health campaigns on hygiene and sanitation, immunization, etc. • Provision of family planning services including family planning products • Community education on use of water treatment solutions and distribution of them	• **Community Case Management of malaria, ARI, diarrhoea, vaccination, malnutrition (i.e. iCCM)** • Community DOTS for TB and HIV	• Nutrition education to communities • Growth monitoring for children under five years old • Nutrition surveillance • Routine home visits for active case finding

Source: (Mugeni, 2011)

10.3 Community performance-based financing (PBF) indicators remunerated

Category	Indicator
Nutrition monitoring	Percent of children monitored for nutritional status
Maternal health	Number of women accompanied/referred to the health center for antenatal care within the first four months of pregnancy
Maternal health	Number of women accompanied/referred to the health center for assisted deliveries
Reproductive health	Number of new users referred by CHWs for modern family planning methods
Reproductive health	Percent of regular users using long term family planning methods (IUD, implant, surgical)
Tuberculosis (TB)	Number of TB suspects referred to the health center by CHWs
TB	Number of TB patients receiving DOTS at home
HIV prevention	Number of couples referred to a health center for prevention of mother-to-child transmission of HIV
HIV prevention	Number of households referred to a health center for voluntary counseling and testing for HIV
Reporting	Number of complete CHW reports submitted

Source: (MoH [Rwanda] Community Health Desk, 2013)

10.4 Partners In Health enhancements to the Rwanda CHW program in southern Kayonza district

Area of support	National system	PIH enhancement
Coverage	1 male and 1 female CHW* per village	1 CHW per ~50 households (2-4 CHWs per village)
	Children visit or are visited by CHWs when sick	CHWs visit all households once a month
Training	4-day iCCM training, 2-day SISCom training for CHWs and supervisors	• Additional CHW trainings on M&E and data use, household register, primary care topics and accompaniment. • Trainings on supervision, M&E and data use for supervisors
Supervision	• Cell-level supervisor trained and functioning as *binôme* carries out monthly supervision visits to all CHWs in cell, using iCCM supervision tool for *binômes* • 2 health center level (non-clinical) supervisors oversees CHW activities and carries out monthly-quarterly supervision visits, using iCCM supervision tool for *binômes*	• Cell-level MoH supervisor replaced with dedicated supervisor with three more years of education • Community health nurse (clinical) supports health center level supervisors • Supervisors to receive additional supervision training and complete general supervision tools during monthly visits
Monitoring and evaluation	• CHWs record data in iCCM sick child form, register, stock cards, referral/counter-referral form and contribute to compilation of village-level monthly SISCom report. • Supervisors compile cell- and health center-level monthly SISCom reports and complete iCCM supervision forms during monthly to quarterly CHW visits	• CHWs use longitudinal register to monitor all households, and complete SISCom and supplemental monthly reports. • Cell CHW and community health nurse supervisors compile CHW reports
Accompaniment	N/A	CHWs trained to perform daily accompaniment for people with HIV, TB and other chronic diseases
Incentives and motivation	• iCCM client fees and quarterly disbursements for timely and complete SISCom reporting feed into sector-level CHW cooperatives. • Cell supervisor does not receive additional compensation	• Direct financial incentives to CHWs as well as cooperatives for timely and complete monthly reporting, monthly meeting and training attendance, and accompaniment. • Cell supervisor receives compensation

10.5 Rwanda MoH iCCM sick child encounter form

FORM FOR THE INDIVIDUAL MANAGEMENT OF THE SICK CHILD BY THE COMMUNITY HEALTH WORKER

1. IDENTIFICATION

District :			**Sector :**		
Date:		**FOSA:**		**Village:**	
Name of child :		**Parent:**		**CHW :**	
Date of birth		**Age :** Years / Mos	**Age in mos:**	**Sex :** F M	**Start of illness :** days

Illness : Fever Y N Diarrhea Y N Cough/Cold Y N Other :… … … … … … … … … … … … … … … .

Received drugs ? Y N If yes, what : ____

2. NUTRITIONAL STATUS

MUAC: cm **or WEIGHT:** kg **Classification:** Green Yellow Red

3. DANGER SIGNS (REFER IF « YES »)

Under 2 months of age	Y N	Difficulty breathing, chest indrawing, stridor (wheezing)	Y N
Severe malnutrition (status red)	Y N	Illness lasting >14 days	Y N
Edema with pitting	Y N	Recurrent illness	Y N
Unable to drink, breastfeed or eat	Y N	Initial treatment without improvement	Y N
Vomits everything	Y N	Fever with rash	Y N
Convulsions	Y N	Bloody stool	Y N
Unconscious	Y N	Under 6 months with fever	Y N
Very weak	Y N	Over 5 years old	Y N
Palmar pallor	Y N		
Dehydration :			
Sunken eyes	Y N	Agitated	Y N
Thirsty	Y N	Skin tenting (poor skin turgor)	Y N
Other ___________________			

Refer: Yes No

4. SYMPTOMS, CLASSIFICATION, TREATMENT & DRUG DISPENSING

SYMPTOMS	CLASSIFICATION	TREATMENT	DOSE GIVEN
Fever Y N	Fever to refer Y N		# Pills times/day # days
	Malaria Y N	Primo Red Yellow	
Diarrhea Y N	Diarrhea to refer		
	Diarrhea to treat Y N	Zinc 5 pills 10 pills ORS 4 packets	
Cough/Cold Y N	Pneumonia Y N	Amox 2-4 mois 5 Cps; 5-12 mois 10 Cps; 13-30 mois 15 Cps; 31mo-5ans 20 Cps	
Respiratory rate= ……. per minute	Cough or cold Y N	Honey/lemon juice Y N	
Loss of appetite or weight	Moderate Malnutrition (yellow) Y N	Mebendazole (> 6 mos) 6 pills	

FORM FOR THE INDIVIDUAL MANAGEMENT OF THE SICK CHILD BY THE COMMUNITY HEALTH WORKER

5. PREVENTION

Vaccinations complete	Y N	Vitamin A received in last 6 months	Y N
Mebendazole received	Y N	Growth monitoring carried out	Y N

6. ADVICE TO MOTHER OR CAREGIVER

Explanation of illness	Y N	Increase quantity of liquids for child	Y N
Explanation of dosage	Y N	Give first dose of treatment	Y N
Continue to feed the child	Y N	Advise when to return if severe illness	Y N

7. FOLLOW-UP OF THE SICK CHILD

A. The sick child was visited because :

1. S/he returned as scheduled: after 2 days Y N after 3 days Y N
2. S/he returns immediately due to severity of disease : Y N
3. Home visit: Y N

B. Has the child's illness become more severe ? (Ask the mother) Y N **If 'yes' refer the child**

C. Does the child suffer from a different illness ? Y N **If 'yes' use a different form**

D. IDENTIFY DANGER SIGNS (IF 'YES REFER THE CHILD TO THE HEALTH CENTER)

Nutritional status red	Y N	Palmar pallor	Y N
Edema (with pitting)	Y N	Difficulty breathing, chest indrawing, stridor (wheezing)	Y N
Unable to drink, breastfeed or eat	Y N	Initial treatment without improvement	Y N
Vomits all that s/he eats	Y N	Fever with rash	Y N
Convulsions	Y N	Bloody stool	Y N
Unconscious	Y N	Under 6 months with fever	Y N
Very weak	Y N		
Dehydratation :			
Sunken eyes	Y N	Agitated	Y N
Thirsty	Y N	Skin tenting (poor skin turgor)	Y N

Classification from the 1st visit		**Symptoms/signs during follow-up**		**Action**
Fever	Y N	Fever	Y N	Refer
Cough		Resp rate … …		
• Cough/cold	Y N	Rapid breathing	Y N	New form
• Pneumonia	Y N	Rapid breathing	Y N	Refer
Diarrhea	Y N	Diarrhea	Y O	Continue

E. ADVICE FOR CONTINUING THE TREATMENT OF THE CHILD :

- **Ask the mother to tell you how she administers the drugs (dose, times, days)**
- **If the mother has administered the drugs correctly, congratulate and encourage her to continue**
- **If the mother mismanaged the drugs, demonstrate and explain how to administer drugs to the child (dose, times/day, number of days), and ask her to practice in your presence. Check her comprehension.**
- **Continue to administer drugs as directed until finished**

F. EVOLUTION OF THE CHILD'S ILLNESS: Recovered Referred to the HC Died Other :__________

10.6 Rwanda MoH iCCM consultation register

MoH iCCM consultation register

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28
					Prevention			Danger signs	Symptoms						Drug distribution (# drugs)								Evolution					
									Fever						Primo													
Date	Names	Age in months	Sex	Mother/Father	Malnutrition consultation	Vitamin A	Vaccination		Before 24 hrs	After 24 hrs	Diarrhea	Cough or cold	Pneumonia	Nutritional status (R, Y, G)	Red	Yellow	Zinc	ORS	Amoxycillin	Mebendazole	Vitamin A	Other, RDT	Referred to health facility	Recovered	Died	Outcome	Received payment	Mutuelle?

10.7 Rwanda MoH SISCom report

MOH MONTHLY REPORT FOR COMMUNITY HEALTH WORKERS' ACTIVITIES

Report done from: O Village O Cell O Cooperative		
Village/Cell/Cooperative:		Year:
District:		Month:
Health center:		Total population in village:
Number of CHWs:	Number who submitted report:	Number children 0-5 years:
Name of supervisor:		Number women 15-49 years:

	A. Treating sick children	Number of children seen	Recovered	Died	Referred to HC
1	Children under 5 years old seen by the CHW				
2	Children under 2 months referred to a Health Center				
3	Children from 6 months to 59 months treated for fever				
4	Children from 6 months to 59 months treated for fever within 24 hrs				
5	Number of children treated for diarhea				
6	Number of children treated for pneumonia				
7	Number of counter-referral forms received [by the CHW]				

	B. Nutrition (weight or MUAC) and vaccination	Number	Recovered	Died	Referred to HC
1	Number of children in green				
2	Number of children in yellow				
3	Number of children in red				
4	Number of children between 9 and 12 months who did not complete vaccinations				

	C. Supervision and meeting/IEC participation	Number
1	Number of visits from a health center staff	
2	Number of visits from the cell level [supervisor]	
3	Number of attendances at CHW meetings	
4	Number of mass education sessions in the community (mass IEC)	

	D. Maternal health	Number
1	Number of women within 4 months of pregnancy referred by CHW to ANC	
2	Number of pregnant women referred to the health center for pregnancy complications	
3	Number of deliveries in this month	
4	Number of women referred by CHW to deliver at the health center	
5	Number of women who delivered at home	
6	Number of women referred to a health center or district hospital after delivery at home	
7	Number of women referred to health center for PMTCT	
8	New women enrolled in family planning program this month	

	E. Those who died at home	Number
1	Number of maternal deaths (during pregnancy or delivery)	
2	Number of under-5 deaths	

	F. Disease follow-up	Number
1	Number of TB suspects referred to the health center	
2	Number of TB patients receiving DOTS at home	
3	Number of polio suspects referred to the health center	
4	Number of measles suspects referred to the health center	
5	Number of households referred to a health center for HIV testing	

G. Drugs and supplies	Original CHW stock	Dispensed	Spoiled/ Damaged	Remaining stock
Pills				
Condom				
Cycle beads				
Contraceptive injectables				
Primo red				
Primo yellow				
Zinc				
ORS				
Amoxicillin				
Mebendazole				
Sur' eau				
Vitamin A				
Bed nets				
TB drugs				
RDT				
Gloves				

H. RDT	Number
RDT done	
RDT+ found	
RDT- found	
Invalid RDT	

Date filled in:		Date received:	
Name and signature:		Name and signature:	

10.8 Household register cover, index of lists and lists 1, 3, 4 and 9

Community health household register

Name_______________________________________

ID#____

Umudugudu__________________________________

Cell____

Health center_______________________________

Sector______________________________________

District_____________________________________

Month_______ Year_______

to

Month_______ Year_______

Lists

1. List of population (all households and their members) (34 pages)

2. List of children under 5 years with malnutrition (red or yellow zone with weight or MUAC)

3. List of women on family planning method (2 pages)

4. List of pregnant women

5. List of persons > 5 years old with cough > 2 weeks (TB suspects)

6. List of patients on accompaniment (except TB and HIV)

7. List of patients on accompaniment for TB and HIV

8. List of deaths

9. List of household visits (45 pages)

10. List of participation in meetings

11. List of supervision visits

12. List of participation in sensitization activities

13. List of training attendance

Notes

List 1. Population (all households and their members). *Leave 3 blank spaces after each household. Read consent form to all households and get signature.*

Consent sign.	HH #	Name – HH member [list head of household first]	Sex		Date of birth			Under 5?	Woman 15-49?	Insurance/ Mutuelle?	Died -- Fill list 8
			M	F	DD	MM	YY	√	√	☐Y ☐N	DD/MM/YY
			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
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			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
			☐	☐				☐	☐	☐Y ☐N	
Subtotals: HHs: ____Pop:_____ Sex: ___ ___								**U5:___15-49:___ No insur:____**			

List 3. Women on family planning method. *Check family planning card*

#	Name of woman on family planning	National ID number	HH #	**Date of birth**	**Method** – check all that apply (if restart another method, write '2')							**DD/MM/YY** started FP method (according to FP card)	**DD/MM/YY dis-continued** FP	**DD/MM/YY re-started** FP if stopped (write reason in Notes)
				DD/MM/YY	Condom	Pills	Depo-provera	Implant	IUD	Tubal ligation	Partner vasectomy			
1				/ /								/ /	/ /	/ /
2				/ /								/ /	/ /	/ /
3				/ /								/ /	/ /	/ /
4				/ /								/ /	/ /	/ /
5				/ /								/ /	/ /	/ /
6				/ /								/ /	/ /	/ /
7				/ /								/ /	/ /	/ /
8				/ /								/ /	/ /	/ /
9				/ /								/ /	/ /	/ /
10				/ /								/ /	/ /	/ /
11				/ /								/ /	/ /	/ /
12				/ /								/ /	/ /	/ /
13				/ /								/ /	/ /	/ /
14				/ /								/ /	/ /	/ /
15				/ /								/ /	/ /	/ /
16				/ /								/ /	/ /	/ /
17				/ /								/ /	/ /	/ /
18				/ /								/ /	/ /	/ /
19				/ /								/ /	/ /	/ /
20				/ /								/ /	/ /	/ /
21				/ /								/ /	/ /	/ /
22				/ /								/ /	/ /	/ /

List 4. Pregnant women

Name of pregnant woman	National ID number	HH #	Woman's date of birth DD/MM/YY	Estimate delivery date if known DD/MM/YY	ANC visit 1 date DD/MM/YY	ANC 2	ANC 3	Place delivered		Actual delivery date DD/MM/YY	Pregnancy outcome			
								Facility	Community		Miscarriage	Stillbirth	Alive	Other
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
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			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐
			__/__/__	__/__/__	__/__/__	☐	☐	☐	☐	__/__/__	☐	☐	☐	☐

List 9. Household visits – Month _______ Year _______

Visit date DD/MM/YY	HH #	Routine visit?	c-IMCI visit	Refer to HC	Observation/Follow-up	HH signature
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		
___/___/___		☐Y ☐N	☐Y ☐N	☐Y ☐N		

 # HHs visited this month: ___________

10.9 Technical basis for LQAS methodology (Aim 1)

Classical LQAS classifies areas into two categories. For the monthly village report data reliability assessment, the aim was to classify a health center as having 'good' or 'poor' village monthly report reliability. Based on conversations with the Community Health Department at PIH in southern Kayonza, 'good' village monthly report reliability was defined as at least 90% of village monthly reports consistent with data captured in the iCCM registers (or encounter forms for southern Kayonza only). 'Poor' village monthly report reliability was defined as less than 70% of village monthly reports consistent with registers (or encounter forms for southern Kayonza only). The department specified the allowable misclassification error at each of these thresholds as 10% or less.

Because there are finite numbers, N, of village monthly reports in a health center, the hypergeometric distribution was used to determine the appropriate sample size, n, and decision rule, d, for the LQAS classifications. Specifically, n and d are chosen, such that

$$P(X < d \mid N, n, p = 90\%) < 10\% \text{, and}$$
$$P(X \geq d \mid N, n, p = 70\%) < 10\% \text{, where}$$
$$P(X = x \mid N, n, p) = \frac{\binom{M}{x}\binom{N-M}{n-x}}{\binom{N}{n}},$$

where M is the integer closest to N*p.

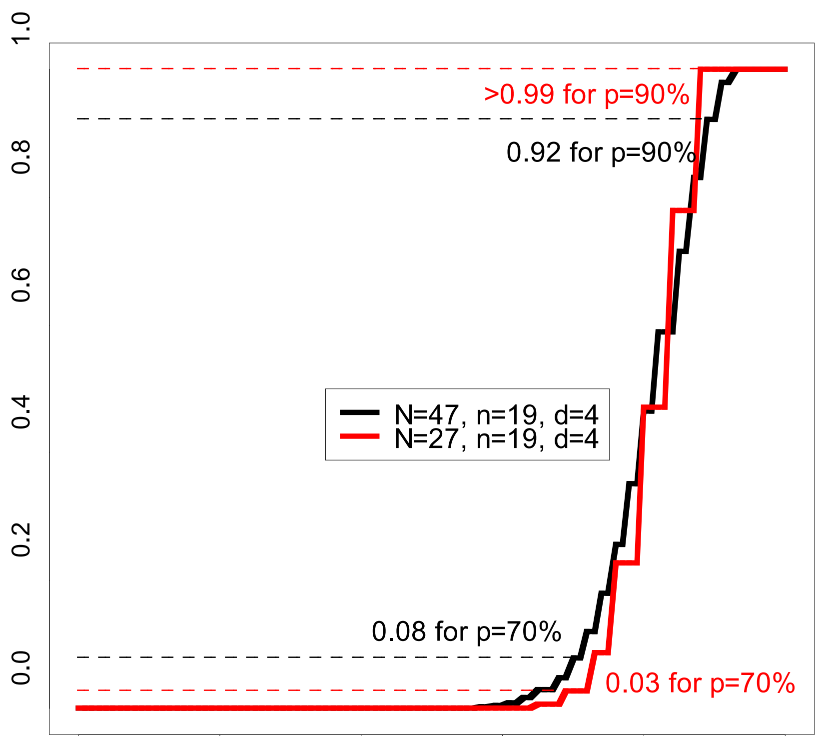
The number of reports varies by center. Developing LQAS systems specific for each health center was considered; however, varying sample size and decision rules by center could confuse implementation. Therefore, one LQAS system was used – one sample size and decision rule (n=19, d=4) – for all areas (within southern Kayonza). This sample size and decision rule meets the constraints for all health centers, and exact errors are reported in Table A.1. Figure A.1 displays the operating characteristic curve (OCC) for two of these systems, HC8 and HC4/HC6. For the largest health center, HC8, the classification system n=19 and d=4 meets the required constraints of reducing misclassification errors to less than 10% for both thresholds. For the health centers with fewer villages, the systems are overly conservative.

Table A.1. Alpha and Beta errors for LQAS classifications for southern Kayonza, with n=19 and d=4

Health center	No. of monthly village reports	Alpha	Beta
SKHC1	45	0.092	0.056
SKHC2	37	0.059	0.06

Health center	No. of monthly village reports	Alpha	Beta
SKHC3	28	<0.001	0.044
SKHC4	27	<0.001	0.027
SKHC5	33	<0.001	0.042
SKHC6	27	<0.001	0.027
SKHC7	7	N/A	N/A
SKHC8	47	0.078	0.078

Figure A.1. The OCC for the LQAS classification system used for the monthly village report data reliability assessment



Note that the system used in this data reliability assessment – n=19 and d=4 – satisfies the misclassification constraints for all health centers in southern Kayonza. This system meets misclassification constraints for health centers with up to 65 villages. Health centers with 65 or more villages (as in Kirehe district) uses the LQAS classification system based on the binomial distribution (not adjusting for finite number of villages) – with n=25 and d=5.

Source: (Mitsunaga T & Hedt-Gauthier B et al., 2013)

10.10 Data collection form for household register data accuracy assessment

Data collection form for household register data quality assessment

Name of data officer:______________________________ **Date of data collection:** ___/___/___

CHW name:____________________________________ **CHW #:** ___ ___ ___-___ ___ ___

Village:________________________________ **Cell:**_________________ **FOSA:**_______________

Household register start month/year: _____/______

Record household number:	__ __ __	__ __ __	__ __ __	__ __ __	__ __ __	__ __ __
HOUSEHOLD VISIT: *during the household visit, ask the most senior household member:*						
# children < 5 years **Ask:** how many children U5 are in HH. Ask to see their growth charts if possible to confirm age.						
# women and girls 15-49 years **Ask:** how many women and girls in HH. Ask for their ages/date of birth. Check their national ID cards if possible to confirm age. Record # women and girls 15-49 years in HH.						
# women on modern family planning method **Ask:** to speak to all women 15-49 years. For each woman, ask if they are on FP. Check their FP card if possible to confirm. If any woman not home, ask most senior household member. For each woman, if no or not modern method, record 'NONE'; if yes, ask what type and record modern method only in small bottom boxes and count in big top box.						
# women delivering at home since start of HH register **Ask:** if any women in HH has given birth since HH register was started. If yes, ask where woman delivered. Record if woman delivered at home/in the community						
HOUSEHOLD REGISTER: *For each sampled household, collect the following from the HH register:*						
# children < 5 years **List 1:** add # children < 5 years in HH						
# women 15-49 years **List 1:** add # women 15-49 years in HH						
For each woman 15-49 above in HH, check box. **List 3**: Then, write in type of MODERN family planning method or 'none' if not in List 3, discontinued, or on other or no method	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
# women on modern family planning method **List 3:** add # women in **LIST 3** using modern family planning method (any one of the method boxes ticked AND woman has not discontinued method)						
# women delivering at home since start of HH register **List 4:** add # women with actual delivery date in time since HH register started AND they delivered at home/in the community						
Household visited in last complete month? **List 9:** Find page with last complete month and check if household visited (HH#)	Y ☐ N ☐	Y ☐ N ☐	Y ☐ N ☐	Y ☐ N ☐	Y ☐ N ☐	Y ☐ N ☐
HH register kept in wooden box? **Ask:** where the CHW stores the HH register	Y ☐ N ☐ If no, write where :________					
Wooden box locked? **Ask:** if CHW locks box when not in use	Y ☐ N ☐					

10.11 Data collection form for monthly report data reliability assessment

Data collection form for SISCom report data quality assessment

Name of data officer:_________________________ **Date of data collection: ___/___/___**

Village	**Cell**	**FOSA**	**Reporting month/year**
# CHWs:	**# CHWs submitted report:**		

Fill numbers from village SISCom report Section A

SISCom report	**Total**	**Recovered**	**Referred**
# sick children seen (A1)			
# children 6-59 months treated for fever within 24 hours referred to health center (A4)			
# children treated for pneumonia recovered (A6)			

Fill numbers for all children seen in reporting month for each CHW in village

Unique ID of all CHWs in village -->	___-___	___-___	___-___	___-___
iCCM consultation register (column)				
Total # children age 0-59 months recorded seen in reporting month (1: Date)				
Total # children who meet all criteria: -(10) Fever < 24 hours checked -(1) Seen in reporting month -(3) Age = 6-59 months -(16) Any Primo distributed -(23) Evolution = referred to HC				
Total # children who meet all criteria: -(14) Pneumonia checked -(1) Seen in reporting month -(3) Age = 2-59 months -(19) Any amoxycillin distributed -(24) Evolution = recovered				
iCCM sick child forms				
Total # children age 0-59 months with a sick child form completed during the reporting month				
Total # children who meet all criteria: -Seen in reporting month -Age = 6-59 months -Start of illness <= 1 day -Symptom: Fever=Y OR RDT=positive* OR -Classification: Malaria=Y -Treatment: Any Primo checked OR Dose given filled -Action=Refer OR Evolution=referred to HC				
Total # children who meet all criteria: -Seen in reporting month -Age = 2-59 months -Symptoms: cough/cold=Y OR respiratory rate is >50 if < 12 months; >40 if 12-59 months OR -Classification: Pneumonia=Y -Treatment: Any amoxycillin checked OR Dose given filled -Evolution = recovered				

*CHWs carrying out RDT were taught to record results in Symptoms: fever section

10.12 CHW questionnaire

CHW questionnaire Today's date: Day___ ___ Month___ ___ Year___ ___ ___ ___

CHW name:_________________________________ CHW ID#: ___ ___ ___-___ ___ ___

National ID #:___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Cellphone number: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Type of CHW: ☐ Cell coordinator ☐ Binôme ☐ ASM ☐ Other

Village:_________________ Cell:___________________ FOSA: _____________ # HHs:_______

Date of birth: Day ___ ___ Month ___ ___ Year ___ ___ ___ ___ Age: ___ ___ Sex: M F

Civil status: ☐ Married or cohabiting ☐ Single ☐ Divorced/Separated ☐ Widowed

Please answer the questions below by checking the most appropriate box(es):

What is your main occupation? ☐ Farmer ☐ Teacher ☐ Informal business ☐ Other:___________________ ☐ None

How long does it take you to walk to your HC? ____ ____ minutes

How many living children do you have? ____ ____

Do you accompany HIV, TB or other chronic care patients? (check one) ☐ Yes ☐ No ☐ Don't know

Are you a member of the sector cooperative COMMITTEE? ☐ Yes ☐ No ☐ Don't know

What is the highest level of education you have received? (check one)
☐ incomplete primary or less
☐ complete primary
☐ incomplete secondary
☐ complete secondary or higher
☐ Don't know

What type of training have you **EVER** received? (Check all that apply)
☐ c-IMCI
☐ PBF
☐ ASM
☐ RapidSMS
☐ m'Ubuzima
☐ verbal autopsy
☐ Vaccinations
☐ Mental Health
☐ TB
☐ Nutrition
☐ HIV/AIDS
☐ Diarrhea
☐ Malaria
☐ Hygiene and sanitation
☐ Reproductive health
☐ Family planning
☐ Household chart
☐ Behavior change communication
☐ Accompaniment (7-day course)

What type of training have you received in the **PAST 6 MONTHS?** (Check all that apply)
☐ Nutrition
☐ HIV/AIDS
☐ Diarrhea
☐ Malaria
☐ Hygiene and sanitation
☐ Reproductive health
☐ Family planning
☐ Household chart
☐ Behavior change communication
☐ Accompaniment (7-day course)
☐ c-IMCI
☐ PBF
☐ ASM
☐ RapidSMS
☐ m'Ubuzima
☐ verbal autopsy
☐ Vaccinations
☐ Mental Health
☐ TB

How many years have you been a CHW? ☐ <1 yr **OR** ☐ ___ ___ yrs

How many times did you receive a cell-level supervision visit in the last month? (check one) ☐ None ☐ 1 to 2 ☐ >2

How long did the last cell-level supervision visit take? (check one) ☐ <30 mins ☐ 30-60 mins ☐ >60 mins

How many times did you receive a health center-level supervision visit in the last 3 months (trimester)? ☐ None ☐ 1 to 2 ☐ >2

How long did the last health center-level supervision visit take? (check one) ☐ <30 mins ☐ 30-60 mins ☐ >60 mins

10.13 Household register consent form

COMMUNITY HEALTH HOUSEHOLD REGISTER CONSENT FORM

The community health worker (CHW) should read the following to all heads of households on the first visit. If he/she agrees to participate, the head of household should sign (1) this consent form and (2) the community health household register.

COMMUNITY HEALTH WORKER (Name) ________________________________

HOUSEHOLD IDENTIFIER: ____

We would very much appreciate your participation of allowing CHWs to keep a community health household register on your household. This register will record all visits to the house include:

- **A list of family members in the household, their age, sex and if they have mutuelle or health insurance;**
- **A list of women using family planning;**
- **A list of pregnant women and the outcomes of their pregnancy;**
- **A list of children under five with potential malnutrition;**
- **A list of persons with cough more than 3 weeks;**
- **A list of patients in chronic care**
- **A list of non-identifiable patients on TB and HIV treatment**
- **A list of any deaths in the household.**

Whatever information you provide will be kept strictly confidential. Participation in this household is voluntary and you can choose not to answer any individual question or to refuse visits by the CHW, CHW supervisor or other visitors coming to verify data collected by the CHW. You may also stop having the CHW visit the house regularly at any time and without any consequences at all.

At this time, do you have any questions on the purpose or content of the Community Health Household register? *[The community health worker should answer any questions if the head of the household says 'Yes'. Otherwise, read the next question]*

Do you agree to participate in having the community health household register monitor information on your family?

If head of household indicates that (s)he agrees to have register monitor information on his/her family, CHW should read the following aloud:

By signing this space in the community health household register, you are indicating that you are agreeing to let us monitor information on your family. You are also indicating that your participation is voluntary and that you understand all information will be kept strictly confidential.

The household head should sign the space next to his/her name in List 1.

Curriculum Vitae

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EDUCATIONAL BACKGROUND

DrPH Johns Hopkins University Bloomberg School of Public Health, **International Health**, Baltimore, MD. Dissertation: *Assessing data quality in the community health worker program in Eastern Province, Rwanda.* Expected April 2014.

ScM Harvard School of Public Health, **Population and International Health**, Boston, MA. Thesis: *Measuring adherence to HIV / AIDS treatment programs in developing countries.* 2004**.**

BA Pomona College, **Asian Studies**, Claremont, CA. Thesis: *The male gaze theory: women in 19th century Japanese literature.* 1996.

PROFESSIONAL EXPERIENCE

World Health Organization (WHO), Department of HIV / AIDS, Geneva, Switzerland
Consultant, December 2013 to present

- Provide technical support for the revision and consolidation of the WHO Patient Monitoring Systems Guidance for HIV care / antiretroviral therapy (ART), maternal and child health / prevention of mother-to-child transmission of HIV (PMTCT) and tuberculosis (TB) / HIV

Partners In Health (PIH), Rwinkwavu, Rwanda
Community Health Research, Monitoring and Evaluation Specialist, December 2009 to August 2012

- Lived and worked in a rural area to support health systems strengthening at the community level across three districts in Rwanda
- Collaborated closely with Rwandan counterparts at PIH and the Ministry of Health (MoH) in a dynamic, multicultural environment to:
  - Provide technical assistance and capacity building for all aspects of community health monitoring and evaluation (M&E) activities in support of the national program including reproductive health, maternal and child health and survival, mobile phone technology, HIV/AIDS, malaria and nutrition
  - Develop and test community health monitoring, reporting and supervision tools and indicators for implementation
  - Support community health data collection, analysis, reporting and feedback
  - Contribute to national community health indicator and policy development

- Participate in the organization of the first international community health conference in Rwanda
- Conduct implementation and evaluation research, including leading the assessment of community health worker data quality and supporting the design, implementation, analysis and dissemination of a national rapid evaluation of the community case management program
- Manage and train team of data collectors
- Create annual program budgets, including strategic objectives, measurable outcomes and indicators for the largest funded department in PIH

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Researcher, June to August 2009

- Carried out systematic review of evidence of outcomes and processes related to coverage, quality of care and equity of implementation of community case management of childhood illnesses (diarrhea, pneumonia and malaria) programs in resource-limited settings

WHO, Department of HIV / AIDS, IMAI Team, Geneva, Switzerland and **MEASURE Evaluation / John Snow, Inc (JSI), Arlington, VA**
Consultant, 2007 to 2009

- Provided technical assistance on development and global implementation of integrated routine patient monitoring systems and accompanying operations manual and adaptation guide for primary health center level HIV care, treatment and prevention services implementation
- Created facility assessment checklists and supported integrated management of adult and adolescent / childhood illnesses model district sites
- Participated in U.S. government (USG)-WHO quality assurance technical work group meeting in Paris
- Participated in PMTCT interagency technical taskforce M&E AFRO consultation meeting to finalize guide in Uganda
- Provided technical assistance to Nigeria MoH to review and revise national HIV care and treatment patient monitoring tools
- Facilitated international HIV care and ART patient monitoring training in Geneva, Switzerland including preparation of materials and presentations and final report

WHO, Department of HIV / AIDS, Geneva, Switzerland
Monitoring and Evaluation Advisor, MEASURE Evaluation / JSI, December 2004 to August 2007

- Global focal point for patient monitoring for HIV care and antiretroviral therapy (ART) including adaptation, implementation, revision and training of the *Patient monitoring guidelines for HIV care and ART* in 12 countries in collaboration and coordination with the United States President's Emergency Plan for AIDS Relief (PEPFAR), USG (USAID, CDC, HRSA) and UN (UNAIDS, UNICEF, WHO) agencies, the Global Fund to Fight AIDS, Tuberculosis (TB) and Malaria and other international partners
- Presented guidelines and accompanying monitoring tools at international meetings and conferences and to national government officials and supporting partner organizations, leading multi-stakeholder discussions on their adaptation into national systems and policies
- Developed and piloted materials and tools to facilitate data collection, aggregation and reporting from district to national level of integrated routine information systems for maternal and child health, TB and HIV care / ART

- Contributed to revision of 2008 UN General Assembly Special Session on HIV / AIDS (UNGASS) indicators, 2009 WHO TB / HIV M&E guide, PMTCT M&E guide and the Global Fund Data Quality Audit tool
- Wrote and coordinated patient monitoring chapter of collaborative WHO-USG-led operations manual and adaptation guide for implementing HIV care, treatment and prevention services at primary health center level

Harvard School of Public Health, Boston, MA
Research Associate, 2004 to 2006

- Analyzed data, wrote scientific paper on prevalence and risk factors associated with alcohol use in urban Moshi, Tanzania

Clinton Foundation HIV / AIDS Initiative, Bahamas
HIV / AIDS Monitoring and Evaluation Consultant, 2004

- Initiated qualitative and quantitative evaluation of the Bahamian HIV / AIDS Treatment Program

AIDS Prevention Initiative in Nigeria (APIN), Harvard School of Public Health, Boston, MA
Research Associate, September to December 2004

- Published scientific paper on risk factors associated with HIV / AIDS-related sexual behavior in Nigeria using Demographic Health Survey data

Medical Care Development International (MCDI), Durban, South Africa
Program Assessment and Evaluation, January 2004

- As part of a team, conducted needs assessment for HIV / AIDS-related stigma and discrimination USG-funded project
- Analyzed data from survey assessing the experience of stigma and discrimination in Kwazulu Natal
- Conducted focus group discussions, participant observation and interviews in Ndwedwe community
- Produced report disseminated among stakeholders, including quantitative and qualitative analyses, and comprehensive literature review

Ministry of Health, Gaborone, Botswana
Monitoring and Evaluation Intern, *African Comprehensive HIV / AIDS Partnerships (ACHAP), June to August 2003*

- Developed draft monitoring and evaluation framework for the National Antiretroviral Therapy Program

Harvard School of Public Health, Boston, MA
Teaching Assistant, *2003 to 2004*

- Assisted in course development, advised students and assessed course assignments for Health Program Planning and Evaluation; SAS Programming and Data Management

Oxygen Media, LLC, ThriveOnline, San Francisco, CA
Associate Medical Producer, Editorial, April 2000 to December 2001

- Researched, produced, edited and wrote medical programming for award-winning women's health Web site

- Collaborated with nonprofit and governmental organizations including the American Lung Association, Centers for Disease Control and Prevention and Agency for Healthcare Research and Quality
- Managed team of four medical experts, and edited weekly columns and reviews
- Produced weekly newsletter distributed to over 20,000 subscribers

ACCESS / Women's Health Rights Coalition, Oakland, CA
Board Member, 2001 to 2002
- Supported strategic planning, financial oversight and fundraising for nonprofit organization dedicated to providing women and girls with reproductive health support and access

Eth-Noh-Tec Creations, San Francisco, CA
Board member, 2001 to 2002
- Oversaw financial performance of the organization, including approving program budgets and grants, and securing individual and corporate contributions
- Participated in strategic planning committee, guiding the focus of future programs and initiatives, fundraising efforts and refocusing the mission

Asian Women's Shelter, San Francisco, CA
Volunteer, 1999 to 2002
- Received 60 hours of training as a domestic violence counselor
- Supported women and their children at a battered women's shelter

Eth-Noh-Tec Creations, San Francisco, CA
Administrative Coordinator, January 1999 to April 2000
- Managed office of international nonprofit performance artist troupe booking over 300 shows a year
- Assisted with grant writing, fundraising campaigns, managing volunteers and interns, event planning, marketing and promotion, graphic design, bookkeeping, maintaining databases and Web site
- Developed internal organizational procedures manual

Okada & Sellin Translations, LLC, Berkeley, CA
Senior Project Coordinator, August 1997 to August 1998
- Proofread and edited technical translations from and into Japanese, French and English
- Coordinated all aspects of translation projects for multi-national corporate clients

JET (Japan Exchange & Teaching) Program, Nagano, Japan.
Assistant English Teacher, July 1996 to July 1997
- Prepared for and team-taught 15 English classes a week at a junior high school
- Participated and aided in the organization of international events and school activities to promote cultural exchange and understanding between U.S. and Japan

COUNTRIES OF PROFESSIONAL WORK

Bahamas, Botswana, Ethiopia, Guyana, South Africa, Japan, Lesotho, Mozambique, Namibia, Nigeria, Rwanda, Swaziland, Tanzania, Uganda, Ukraine, Viet Nam.

PUBLICATIONS, PRESENTATIONS AND AWARDS

Publications

Hedt-Gauthier B, **Mitsunaga T**, Hund L, Olives C, Pagano M. The effect of clustering on Lot Quality Assurance Sampling: a probabilistic model to correctly calculate sample sizes with an illustration of community health worker data quality assessments. *Emerging Themes in Epidemiology*. 2013;10(11).

Mitsunaga T, Hedt-Gauthier B, Ngizwenayo E, Bertrand Farmer D, Karamaga A, Drobac P et al. Utilizing community health worker data for program management and evaluation: systems for data quality assessments and baseline results from Rwanda. *Social Science & Medicine*. 2013;85(0):87-92.

Mitsunaga T, Larsen U. Prevalence of and risk factors associated with alcohol use in Moshi, Northern Tanzania. *Journal of Biosocial Science*. 2008;40(3):379-99.

Mitsunaga T, Powell A, Heard N, Larsen U. Extramarital sex among Nigerian men: polygyny and other risk factors. *Journal of Acquired Immune Deficiency Syndromes*. 2005;39(4):478-88.

Mitsunaga T, Larsen U, Okonofua F. Risk factors for complications of induced abortions in Nigeria. *Journal of Women's Health*. 2005;14(6):515-28.

Presentations

Farmer DB, Ngizwenayo E, Niyigena P, Mazin C, Berman L, Ryan G, **Mitsunaga T**, Palazuelos D, Rich ML. *Supporting Rwanda's national community health program: insights from a community partner organization*. 141st Annual Meeting of the American Public Health Association, Boston, MA. November 2013. Session No. 286939.

Mitsunaga T, Hedt-Gauthier B, Ngizwenayo E, Bertrand Farmer D, Karamaga A, Drobac P, Basinga P, Hirschhorn L, Rich M, Ngabo F, Mugeni C. *Utilizing community health worker data for health systems strengthening: routine data quality assessments and baseline results from Rwanda*. Second Global Symposium on Health Systems Research, Beijing, China, 2012. Poster session.

Mitsunaga T, Hedt-Gauthier B, Ngizwenayo E, Bertrand Farmer D, Karamaga A, Drobac P, Basinga P, Hirschhorn L, Rich M, Ngabo F, Mugeni C. *Improving child health data quality by community health workers: a routine system and baseline results*. Annual International Child Health Conference, Kigali, Rwanda, 2012. Oral session.

Mitsunaga T, Mugeni C, Ndabarora E, Rukundo A, Mukerabirori A, Langston A, De Naeyer L, Ngabo F, Salmon, J. *Community case management of under-5 illnesses: results from a rapid evaluation of Rwanda's national program*. First International Summit on Community Health, Kigali, Rwanda, 2011. Abstract No. 66.

Langston A, Mugeni C, Ndabarora E, Rukundo A, Mukerabirori A, **Mitsunaga T**, De Naeyer L, Ngabo F, Salmon, J. *Community health worker supervision and supply management: results from* *a rapid evaluation in Rwanda*. First International Summit on Community Health, Kigali, Rwanda, 2011. Abstract No. 21.

Farmer Bertrand D, Mugeni C, Binagwaho A, Drobac, P, Ngizwenayo E, Niyigena P, Nsabimana V, Ndanurura D, Rudasingwa D, **Mitsunaga T**, Sosin A, Rich ML *The role of partners in strengthening community health systems*. First International Summit on Community Health, Kigali, Rwanda, 2011. Abstract No. 28.

Farmer Bertrand D, Niyigena P, Nsabimana V, Buckman G, Ngonga G, Ngizwenayo E, Ndanurura D, Rudasingwa D, **Mitsunaga T**, Srivastava P, Niyigena JW, Rich ML. *Accompaniment: improving adherence for chronic communicable and non-communicable disease treatment through community-based service delivery*. First International Summit on Community Health, Kigali, Rwanda, 2011. Abstract No. 62.

Farmer Bertrand D, Mugeni C, Ngizwenayo E, Ndanurura D, Rudasingwa D, **Mitsunaga T**, Rich ML. *Women, health and socio-economic development: evidence from the Rwandan community health program*. First International Summit on Community Health, Kigali, Rwanda, 2011. Abstract No. 61.

Farmer Bertrand D, Mugeni C, Ngizwenayo E, Ndanurura D, Hoepf M, Rudasingwa D, **Mitsunaga T**, Rich ML. *A comprehensive community health worker network to support district health systems strengthening for universal access to health care in Rwanda*. First Global Symposium on Health Systems Research, Montreux, Switzerland, 2010. Poster No. 515.

Mitsunaga T, Boone D. *Harmonizing HIV Care / ART National Patient Monitoring Systems*. 34th International Conference on Global Health, Washington DC, 2007. Poster No. 31.

Mitsunaga T, Seung K, Celletti F, Gove S. *Operationalizing patient monitoring for HIV care and ART*. AIDS 2006 - XVI International AIDS Conference, Toronto, Canada, 2006. Abstract No. CDE0142.

Mitsunaga T, Seung K, Celletti F, Gove S. *Operationalizing patient monitoring for HIV care and ART*. The President's Emergency Plan for AIDS Relief (PEPFAR) Annual Meeting, Durban, South Africa, 2006. Abstract No. 292.

Mitsunaga T, Gove S, Celletti F, Seung K, Gilks C. *Patient monitoring for HIV care and ART: facilitating effective management of patients and programmes*. 14th International Conference on HIV / AIDS and Sexually Transmitted Infections in Africa (ICASA), Abuja, Nigeria. 2005. Abstract No. 187944.

Heard N, Adedimeji A, **Mitsunaga T**. *Barriers to use of condoms among Nigerian men: attitude and proximity*. XXVth International Population Conference of the IUSSP, Tours, France. 2005. Session No. 166.

Heard N, Adedimeji A, **Mitsunaga T**. *Barriers to use of condoms among Nigerian men: attitude, cost and physical access*. Population Association of America Annual Meeting, Philadelphia, PA. 2005. Session No. 141.

Mitsunaga T, Larsen U, Okonofua F. *Risk factors for complications of induced abortions in Nigeria*. 132nd Annual Meeting of the American Public Health Association, Washington DC. November 2004. Session No. 3070.0.

Awards

Saltonstall Population Innovation Fund, *Graduate Associate*. 2003 to 2004.
International Health Departmental Scholarship. *Recipient.* 2007 to 2009.
Framework Program in Global Health, *Grant Recipient***.** 2009

LANGUAGE SKILLS

English (native); French (working knowledge); Spanish, Japanese (conversational).

COMPUTER SKILLS

Stata, SAS, ATLAS.ti, EpiInfo, Microsoft Word, Excel, Power Point, Access, ArcGIS, Front Page, HomeSite, Interwoven, Adobe Photoshop, QuarkXpress, HealthMapper, FileMaker Pro, Rainman, Final Cut Pro, Media Cleaner.